WATER RESOURCES BOARD

Water Supplies in South East England

LONDON

HER MAJESTY'S STATIONERY OFFICE

1966

WATER RESOURCES BOARD

WATER SUPPLIES IN SOUTH EAST ENGLAND

Introduction

1. The South East Study* estimated that during the period 1961-1981 the population of South East England was likely to increase hy another 3½ million, mostly hy the process of natursl growth. Present information suggests that the growth between 1964 and 1981 will he ahout 2.9 million of which 2.2 million would he the natural increase of the resident population. London ovsrspill during the same period is put at 1 million. An increase of this order, together with a rising consumption per head of population, make it imperative that attention he given to the prohlems associated with providing that population with adequate water supplies, and as foreshadowed in the South East Study those prohlems were among the first to which we turned our attention.

2. Following puhlication of the South East Study, the Ministry of Houaing and Local Government commissioned a firm of consulting engineera, Messrs. Binnie and Partners, 'to study and report upon the exploitshle reserves of watsr in the Great Ouse hasin with a view to the preparation of a comprehensive programme of co-ordinated development of the ground snd surface water ressrves of the hasin'. We have considered the consultants' report, and it has heen most useful to us in our examination of the position in South East England.

3. It is ohvious, however, that South East Englsnd muat he considered as a whole and we therefore resolved to seek a comprehensive report on ths water resources of the whole area up to the yesr 2001 as a hase on which to settle policy. To make such a report we ohtained the help of the ten river authorities in South East England and the corresponding area committees of the British Waterworks Association. They readily agreed to our suggestion that their engineers should serve on a Technical Committee charged with making the overall survey we had in mind. The Committee have now made a report to us and a copy ia attached hereto. We are glad to acknowledge our indehted-ness to the memhers of the Committee for producing in just over twelve months such a wide ranging report on a suhject of great complexity. We emphasise, however, that the report is in no way hinding either upon them personally or upon their respective authorities and srea committees.

4. The river authorities have the responsihility under aection 14 of the Water Resources Act 1963 for preparing surveys of the resourcea of their areas and plans to meet future demands for water. Heavily engaged as they have heen with the task of licensing existing ahstractions the river authori-ties have not yet heen ahle to csrry out these surveys. Meanwhile, we have a duty under section 12 of the Act to consider what action needs to hs taken to safeguard water supplies and to advise the Minister and the river authorities. The needs of the South East are too pressing to permit us to await the section 14 proposals of the river suthorities, although this would have made our task much easier. Indeed, the river authorities will need some guidance from ua hefore they can formulate their own proposals hecause the problems go heyond their separate sreas. Some, for example, must know whether and if so how they can expect to get supplies from other areas and others, conversely,

---

* *The South East Study. H.M.S.O., 1964.*

must know whether they will be called upon to provide supplies outside their own areas. We hope that this report will provide the necessary regional framework within which the river authorities can plan. We look forward to consulting them about our recommendations.

5. The report deals with demands and resources up to the year 2001 in the areas of the ten river authorities together with the London Excluded Area (hereinafter referred to as London). The whole area investigated is shown on the map accompanying this report, and it contains a population of about 19 million using at the present time about 1,750 m.g.d. (million gallons per day). In succeeding paragraphs we discuss the Committee's conclusions on the probable growth in demand for water in the area and on the resources which can be made available to meet it.

Demands for water

(a) Public water supply

6. In Chapter 2 of their report the Committee describe the existing demands on and resources of the 131 statutory water undertakings responsible for the public water supply system of the area and explain how they have estimated future demands. They include allowances for the new and expanded towns contemplated by the Ministry of Housing and Local Government. We have examined these estimates with care and are satisfied that they provide a reasonable basis on which to plan. The prudent course, which has been adopted by the Committee, is to plan generously for the near future to avoid being caught short of water with no time to develop extra supplies; and conversely to envisage more modest rates of increase in the distant future so as to avoid commitment to heavy capital expenditure which may prove to be unnecessary, there being ample time to revise the programme of works if a regular review of the estimates so indicates.

7. The Committee then examine the balance between demands and resources for statutory water undertakings. While an apparent balance for each undertaking can be obtained by subtracting resources from demands they point out that resources and demands cannot simply be totalled over a river authority area as a whole because of successive re-use of water. This facility is important, particularly in the Great Ouse and Thames areas. It does, however, give rise to pollution problems, and we refer to these in paragraphs 33 to 36 below. After making an allowance for re-use (in the way described in paragraph 3.3 of their report) the Committee estimate the effective internal deficiency in each river authority area. The deficiencies are summarised in the following table:-

TABLE I

PUBLIC WATER SUPPLY

River Authority Area	Authorised Resources m.g.d.	Estimated Effective Deficiencies (to nearest 5 m.g.d.)		
		1971	1981	2001
Welland and Nene	32	–	30	75
Great Ouse	99	15	30	65
East Suffolk & Norfolk	62	–	10	30
Essex	74	30	80	150
Lee	103	–	20	85
Thames (inc. London)	580	10	55	185
Kent	138	5	20	85
Sussex	66	5	10	35
Hampshire	65	10	45	115
Avon & Dorset	75	–	5	35
Totals	1294	75	305	860

(b) Direct industrial demand

8. Until licensing by river authorities under Part IV of the Water Resources Act 1963 provides reliable figures for present direct industrial use of water, estimates are liable to error. Nor is the forecasting of long term future demands easy because, not surprisingly, industrialists are generally unable to estimate their future requirements for more than 5 to 10 years ahead. Similarly, the Central Electricity Generating Board do not normally make precise estimates far beyond the next decade. Nevertheless, we share the view of the Committee that we must allow for some increase in direct industrial use (i.e. use of water in addition to that obtained by industry from the public supply) and bearing in mind the probable growth in demand for electricity we do not regard their estimates as excessive. For present purposes, therefore, we are adopting their estimates which are shown in the following table:-

TABLE II

ESTIMATED INDUSTRIAL DEMAND

River Authority Area	Average Daily Use - m.g.d.						Additional net demand - m.g.d.		
	Gross Use 1965		Net Use including C.E.G.B.						
	Excluding C.E.G.B.	C.E.G.B.	1965	1971	1981	2001	1971	1981	2001
Welland and Nene*	19	80	14	17	21	35	3	7	21
Great Ouse	35	60	12	15	36 (16)	74 (44)	3	24	62
East Suffolk and Norfolk	15	20	5	7	10	15	2	5	10
Essex	38	–	19	24	31	45	5	12	26
Lee	33	90	11	14	26 (8)	35 (8)	3	15	24
(Thames	50	120	5	10 (3)	30 (20)	63 (48)	5	25	58
(London Excluded Area	30	–	30	30	30	30	–	–	–
Kent	80	–	60	64	70	80	4	10	20
Sussex	4	–	2	2	3	4	–	1	2
Hampshire	8	–	5	5	6	7	–	1	2
Avon and Dorset	4	–	2	2	3	4	–	1	2
Total Industrial Use	316	370	165	190 (3)	266 (44)	392 (100)			
	686								
Total Additional Net Demand							(to nearest 5 m.g.d.)		
							25	100	225

NOTES: *Figures in brackets indicate demands by the Central Electricity Generating Board which have been included in tabulated figures; the allocation between Thames, Lee and Great Ouse must be regarded as flexible.*

** Including Corby and District Water Co. (Stewarts and Lloyds).*

(c) Agricultural demand

9. In Chapter 5 of their report the Committee examine in detail the probable growth in demand for water for spray irrigation. They take the view that there is unlikely to be any substantial increase in the demand for water for stock watering, washing, milk cooling and other general farm uses and that such increases as will occur will be covered by the allowances made for increased public water supplies. We accept that spray irrigation is likely to be the largest single factor in the agricultural demand.

10. The use of water for spray irrigation differs from many other uses in that the water is almost entirely lost to the source of supply by the

processes of evaporation and transpiration. This is not, of course, wasteful if it leads to increased production. The Committee examine the probable future demand in each of the ten river authority areas on the bssis of low value crops, principally grassland and sugar beet, and high vslue crops, principslly potatoes, other vegetables and orchard fruits. The assumption is made that in general the low value crops will make sn effective demand only in so far as water is available for abstraction from inland waters during the irrigation sesson without conservation works but that the bigh value demand will justify expenditure on conservation works, controlled ground-water abstraction snd, where necessary, tbe import of water from other river authority areas. Tbeir conclusions about effective peak seasonal demand are set out in the following table:-

TABLE III

SPRAY IRRIGATION

ASSUMED EFFECTIVE PEAK SEASONAL DEMAND

River Authority Area	Millions of Gallons			
	(to naarast 100 m.g.)			(to naarast 500 m.g.)
	1965	1971	1981	2001
Welland and Nene	600	800	1,200	2,000
Great Ouse	4,300	6,300	8,400	10,000
East Suffolk and Norfolk	3,200	3,900	4,700	5,000
Essex	1,700	2,200	2,800	3,000
Lee	400	500	800	1,000
Thames	1,800	2,300	2,800	3,000
Kent	2,300	3,000	4,200	6,000
Sussex	700	1,000	1,000	1,000
Hampshire	400	700	1,000	1,500
Avon and Dorset	1,500	1,800	1,900	2,000
Totals (to nearest thousand m.g.)	17,000	23,000	29,000	35,000

The Committee expect most of tbis demand to be met by the development of local farm storage or the use of ground water and with the exception of the Essex and Lee areas do not contemplate tbat water will be imported to meet it. In a dry year the amounts needed to be imported into the Essex and Lee areas will be equivalent to averages over the year of 7 m.g.d. in 1971 and 11 m.g.d. in 2001 and are marginal in relstion to the totals for public water supply and industry shown in Table IV.

11. We must emphasise tbat the Committee's estimates of future demands for agriculture are extrapolations from a very limited base period, snd, subject as they are to unforeseesble economic and political influences, they must be regarded as speculative. Nevertheless, since we consider tbe Committee's approach is reasonable we accept their estimates for the purposes of this report. The figures will need to be reviewed frequently in the light of any new factors.

(d) Additional supplies required

12. We consider, therefore, thst, on the best estimates at present available, the effective future water deficiencies in the river suthority areas of South East England are as follows:-

TABLE IV

FUTURE WATER DEFICIENCIES

River Authority eraa	Total deficiencies (to nearest 5 m.g.d.)		
	1971 m.g.d.	1981 m.g.d.	2001 m.g.d.
Welland and Nene	5	35	95
Great Ouse	20	55	125
East Suffolk and Norfolk	5	15	40
Essex	35	90	175
Lee	5	35	110
Thames (including London)	15	80	245
Kent	10	30	105
Sussex	5	10	40
Hampshire	10	45	115
Avon snd Dorset	–	10	40
Totals – to nearest 100 m.g.d.	100	400	1,100

As the tsble shows, however, the total deficiency is not evenly spread over the whole area. In relation to authorised resources it is most marked in the Essex, Lee and Welland and Nene areas. Our next concern muat he to examine the resources which can he used to meet the deficiencies with a view to determining more precisely the sress of difficulty and considering how hest to tackle the joh of augmenting resources to meet demands.

Resources to meet demands

(a) Existing sources of supply

13. The Committee list in Appendix I to their report the existing and authorised resources availahle to the statutory water undertakings in each river authority ares. The sum of those resources, nesrly 1,300 m.g.d., exceeds the present demend upon them and if they could be distrihuted over the whole area according to need they would suffice until just after 1971. However, this is ohviously not practicahle and in the Committee's view only three major surpluses can he applied to meet deficiencies elsewhere, namely those of the Metropolitan Water Board, the Oxford Corporation and the Great Ouse Water Authority. We refer agsin to these surpluses in paragraph 26 helow.

(h) New sources of supply

14. The Committee considered some 130 schemes put forward hy their memhers for increasing supplies. The schemes sre listed in Appendix IV to the Committee's report. They are at various stages of development ranging from outline proposals not yet critically investigated to detsiled projects for which statutory powers have heen sought. Many are of local significance only, capahle of meeting local needs and so reducing the total overall deficiency, hut not hig enough to make a wider contrihution. The Committee classified the schemes in four cstegories:-

(i) suitahle to meet immediate local needs;

(ii) major schemes within s river authority srea;

(iii) regional schemes; and

(iv) barrages.

A compsrison of future demands with these possible new sources of supply in each of the ten river authority areas shows that while some river authorities

have potential resources adequate to meet demands until 2001, others will have to get help from outside their own area and get it quickly.

(c) The deficiency zone

15. It is clesr that London and the Essex and Lee areas will not he shle to meet their demands from internal resources. The Welland and Nene River Authority will also need outside resources to supply parts of their area. The Committee's survey of future demands and resources reveals that the main prohlem lies in a hroad deficiency zone running in a hroad sweep from north of Northampton south to the London hasin and eastwards across Essex. This deficiency zone extends into tbe sreas of the Welland and Nene, Great Ouse and Essex river authorities, of the Thames and Lee Conservancies and of parts of the East Suffolk and Norfolk and Kent river authorities. The Committee refer to these areas as the central area within which they estimate that the following deficiencies will arise:-

1971:	85 m.g.d.
1981:	270 m.g.d.
2001:	650 m.g.d.

These deficiencies are suhstantisl psrts of the totsls for South East England set out in paragraph 12 ahove.

(d) Self sufficient areas

16. The remaining five river anthorities should he able to meet their demands from resources in their own aress:-

East Suffolk snd Norfolk (excepting the Ipswich and South-East Snffolk areas)

Kent (outside the limits of the Metropolitan Water Board)

Sussex

Hampshire

Avon & Dorset

The Committee list in Chapter 7 and Appendix IV of their report scbemes which appear to them to be appropriate. We recognize that some of the schemes are likely to be opposed, particularly those requiring surface reservoirs such as the Bewl Bridge scheme in Kent and the Cuckmere scheme in Sussex. We have considered whether this justifies importing water from outside these aress. Our present conclusion is thst it would not. We agree with the Committee that these aress should rely upon their own resources for many years to come. Three reasons seem to us to he decisive. First, if short-term demands are to be met, there is no alternative to at least one reservoir in the Kent area: timing alone rules out importing water from elsewhere. Second, if storage is not to he provided in these areas, it may well have to be found elsewhere in South Esst England: such a shift of the hurden does not appear to us to be tbe right answer. Third, the cost of importing the qusntities of water involved would be high because of the long and large aqueducts required. Nevertheless, tbe situation should he re-examined in the light of decisions which will need to he tsken in the early 1970's ahout the long term programme for the rest of the South East with a view to determining what contribution, if any, that programme can make towsrds meeting deficiencies in these areas

snd, conversely, what demands it may have to make on these areas. We shsll, of course, discuss the problems of these five areas with each of the river authorities concerned, since they will be responsible under section 14 of the Water Resources Act 1963 for formulating detailed propossls for action to augment water resources in tbeir respective areas.

The problem of the deficiency zone

17. Supplying the deficiency zone is undoubtedly the main problem in South East England. This is beyond the resources of any one water undertaking or river authority. However, as the Committee's report suggests, when tbe problem is tackled on a regional basis the region as a whole has tbe resources to meet most of its needs to tbe turn of the century. The Committee's conclusion is that, given extensive re-use of water, the most economic and beneficial way of meeting the deficiencies is by a programme of controlled ground-water development and pumped storage reservoirs perhaps supplemented in tha last decade of tbis century by transfer of water into the river Thames from the West or the South.

The various ways of increasing supplies

18. The vsrious ways of incressing supplies in the deficiency zone csn be clsssified as follows:-

(1) importing water from outside - in effect from the Severn and/or the Wye or from tbe South (Hampshire, Avon and Dorset) with the possibility of transfer from the Trent if tbe quality of the water in that river can be improved sufficiently;

(2) estuarial barrages, particularly the Wasb;

(3) desslination;

(4) artificial rechsrge of aquifers;

(5) surfsce storage in reservoirs used either to regulate river flows or to augment supplies direct from storage;

(6) exploitation of wster in underground strata, mainly tbe chalk aquifers in the Thames and Great Ouse areas by direct abstraction to supply or by controlled pumping to augment river flows.

Importing water from outside

19. Tbeoretically the long term problem could be tackled on a national ratber than a regional basis. All the necessary additional supplies could be brougbt into the Thames from the Severn snd Wye rivers, or water could be brought to the South East from barrages across Morecambe Bay or tbe Solway Firth by a gigantic pipeline. Another proposal is the 'Grand Contour Canal' to bring to tbe South East water from tbe North and West. In our view these are not practical alternatives, at least for present planning. The Grand Contour Csnal is an imaginative but very expensive proposal. Moreover, it would not obviate storage since the water it would convey would need to be conaerved in reservoirs in tbe Northb and West. Tbe canal itself would also require lsrge sreas of land involving considerable disturbance. A large scale transfer of water from the Severn or Wye into the river Thames would require very lsrge storage in the form of either regulating reservoirs in the Welsb

mountains or pumped atorage reservoirs in the Severn or Thames areas as well as engineering works to lift the water into the Thames area. Sites for all these works would have to he found and investigated. Several years at least would he needed to study the feasihility of bringing in water from harrages in the North West, while the cost of such water ia likely to he very much greater than of that ohtained by developing resources availahle within the region. We therefore accept and endorse the Committee's view that we should look first to the resources of the South East to meet demands there, leaving outaide aupplies for the future when their feasihility and cost can he weighed against any alternatives then available. We shall, however, make an early start on studying, in consultation with the river authorities concerned, the prohlems of supplementing the flow of the river Thames hy the transfer of water from the West and South.

Barrages

20. The cumulative deficiency in the central area at the end of the century - 650 m.g.d. - is comparahle with the yield estimated for a harrage across the Wash. The Report on the Water Resources of the Great Ouse Baain (referred to in paragraph 2 ahove) suggested that this might provide ahout 620 m.g.d. for a capital outlay of £287 millions at today's prices. A harrage scheme, however, could not he relied upon to he completed hefore the early 1980's and therefore cannot help to meet demands hefore then. Nevertheless, a feasihility study should he undertaken without delay, as the Committee recommend, so that the facts about ohtaining water in this way may he availahle for comparative appraisal later with the prospects for hringing in water from the Severn or Wye or elsewhere.

Desalination

21. The Committee regard desalination aa unlikely to play any important part in meeting demands, certainly until 1981, mainly on grounds of cost. They acknowledge, however, that developments in technique or changea in fuel cost may alter the picture so that the position will need to he kept under constant review.

22. The present position is that multi-stage flash distillation is the most promising method of desalination for the production of water in large quantities. While design studies for much larger units have been made, the largest operating unit of this type in tha world has, however, a capacity of only 1.4 m.g.d. and the cost of water ao produced, using an independent aource of ateam, is two to three timea the cost of water ohtainahle in other waya in the South East. In consultation with the Atomic Energy Authority and the Central Electricity Generating Board we are closely watching the work now being done hoth in Britain and in the U.S.A. to design larger plants capahle of producing water in this country at much more competitive coats. One of the most encouraging developmenta in thia respect is a deaign study for a comhined advanced gas-cooled reactor nuclear power atation and diatillation plant to produce 400 M.W. of electricity and 60 m.g.d. of water.

23. We are informed, however, that auch a specially deaigned nuclear power station could not he in operation hefore the mid 1970's. For the immediate future, therefore, desalination is unlikely to play a significant part in meeting demands. In addition, we need to learn a good deal more ahout the practical prohlems associated with the introduction of large quantitiea of desalted water into the puhlic water supply system of this country. To do this we need operational experience of a large acale plant and we are

currently exploring with the Government Departments concerned the prospecta for an experimental plant in South East England. Desalination may yet play a part in the last two decades of this century.

Artificial recharge of aquifers

24. No large-scale scheme designed specifically for artificial recharge of defined aquifers is in operation in this country, although several operators, including the Metropolitan Water Board, have demonstrated the possibilities of the process. After identification of those areas where artificial recharge might help to augment supplies, further investigations, including research in certain fields, will be required to define the hydro-geological conditions, to assess the optimal design for engineering works and to consider the most suitable sources of water, in respect of both quantity and quality, for recharge operations. Cost-benefit analysis may be required to study the economic effectiveness of artificial recharge in specific areas in relation to other conventional means of augmenting supplies. We have made a start on collecting the hydrogeological data which is an essential preliminary to all this.

A progressive development programme

25. None of these various ways of increasing supplies discussed in paragraphs 19 to 24 can be relied upon to meet demands during the next ten years. This leaves only exploitation of water in underground strata and surface storage. These considerations lead us to accept the Committee's suggestion that what is required is a progressive programme of development. The first stage of such a programme must be to make full use of all additional supplies which can be obtained fairly quickly from works already authorised and to authorise new works which will take full advantage of existing river flows without requiring big new storage reservoirs. Next we must seek to obtain the maximum yield from underground resources, so reducing to a minimum any interference with existing land use and amenity besides avoiding large capital investment at the outset. The Committee hope that large additional supplies can be obtained in this way in both the Thames and Great Ouse areas. If investigations (see paragraphs 29 to 30 below) show that these hopes can be realised, then, with the exception of one major scheme the construction of big new surface reservoirs can be postponed until a later stage, say after 1975. This will allow time for studies to be undertaken of other possibilities such as a Wash barrage and desalination and a comparison made between them and the later stages of a progressive programme of underground and surface storage.

26. We therefore recommend that:-

(1) the works of the Great Ouse Water Authority at the Diddington reservoir should be expanded to their full capacity at an early date;

(2) Datchet reservoir should be constructed as soon as possible, as planned by the Metropolitan Water Board;

(3) the proposal for construction of a supplementary intake to the Diddington reservoir from the River Great Ouse should be proceeded with urgently;

(4) the scheme for pumping water from the Ely Ouse into the head waters of the River Stour and other rivers in the Essex area should be investigated by the river authorities concerned and steps should be

taken to put that scheme into effect at the earliest possible date and to provide appropriately increased intake capacities at Abberton and Hanningfield Reservoirs;

(5) to help meet increased demands on the Colne Valley Water Company, the Rickmansworth and Uxbridge Valley Water Company and the Lee Valley Water Company, the conatruction of intake works near Sunnymeada on the River Thames and the neceasary pipelines should proceed. In our opinion, however, these worka should be accompanied by othera which will enable abstraction to be made without reducing the statutory minimum flow over Teddington Weir. This can be done in two waya: by the Thamea Conservancy's ground-water scheme and by constructing Stage II of the Farmoor reservoir and using it to regulate the river;

(6) the ground-water resources in the Peterborough area and adjoining parts of tbe Lincolnshire River Authority area ahould be developed to keep pace with requirements in that locality;

(7) certain local schemes will alao have to be undertaken in Essex and East Suffolk to relieve tbe ahort-term deficienciea of those areas.

27. Even if the ground-water schemes in the Thamea and Great Ouse areas are developed successfully as quickly as we hope tbere will still be a deficiency in the central area reaching about 20 m.g.d. by 1981. This can only be met by a surface storage acheme. In view of the rate of growtb of demand in the Welland and Nene area and its remoteness from the ground-water schemes it would be preferable to provide tbe necesaary atorage in that area by building eitber tbe Manton or the Empingham reservoir.

28. If our hopes for appreciable ground-water yields are not fulfilled new surface storage is the only alternative wbich can poasibly be ready in time to meet demands in the early 1970's. It is, therefore, easential that full site investigations are carried out immediately so tbat alternative supplies can be developed if the ground-water investigations show that they will be needed. To this end we recommend the following programme of reservoir site aurveys and explorations:-

(a) <u>To be completed and reported on by the end of 1967</u>

1. Waddeadon
2. Whitchurch
3. Manton
4. Empingham
5. Great Bradley

(b) <u>To be completed and reported on by the end of 1969</u>

6. Cobbins Brook
7. Abbotsley

We wish to emphasiae that the investigations in group (a), where not already under way, should be put in hand as quickly as possible.

Importance of ground-water investigations

29. If, as we think is right, demands are to be met by a progressive scheme of development which offers scope for a full re-appraisal in the early 1970's, we cannot overstress the vital importance of an early start on pilot schemes for developing the ground-water resources of the Thames and Great Ouse areas. We recognise, and understand, the desire of those likely to be affected by the schemes to be assured that their interests will be safeguarded, but demands are pressing and already objections to proposals for a pilot scheme in the Lambourn Valley hsve caused a serious loss of time wbich we can ill afford. The pilot scheme, and a similar scheme in the Great Ouse ares, are essential to determine the validity of the objections as well as the feasibility of the whole projects.

30. We accept that the proper interests of the existing water undertakings in the area must be safeguarded; it will be our concern to secure tbis. At the same time, however, we cannot accept that because an undertaking's area embraces undeveloped sources of supply thst undertaking sbould slways have exclusive claim to those sources even to the extent of inbibiting their wider and more productive use. For the same raasons we agree with the Committee tbst a review should be made of the Metropolitan Water Board's statutory powers of abstraction from tbe River Thames since in tbeory thase could frustrate tbe licensing of other undertakings to take advantage of augmented flows in the river.

Conclusions on the problem of the deficiency zone

31. As we see the problem, therefore, two things are necessary: (1) immediate action to secure the position for tbe next decade and (2) reconnaissanca in deptb before determining strategy for tbe years thereafter. Immediate action will involve completion of works already autborised and execution of new ones as described in paragraph 26 above. Reconnaissance will cover exploration of the reservoir sites listed in paragraph 28, the pilot ground-water schemes in the Thames and Great Ouse areas and investigation of other possible ways of augmenting supplies sucb ss the Wash barrage, imports from outside the South East and so on. Bearing in mind tbe rate of growtb of demand and the time naeded to build the large-scale works involved, reconnaissance will need to ba completed by the early 1970's.

32. In reaching tbese conclusions we have had rsgard to the many factors which must be weighad in planning for the future such as competing land use, amenity, social and economic policies and not laast, capital and operating costs (whicb economic necessity may make tha decisive factor). All factors are present to a greater or lesser extent in any development scbeme, and the vslue to be given to eacb must ultimately be a matter of opinion.

Problems of re-use of water

33. The concept of re-use of water is fundamental botb to the assessment of future demands and to the programme proposed to meet tbose demands. Repeated use of water offers grest savings in capital and in land. Without the allowances for future re-use of water for the public supply which are made in the Committee's report the new resources required in the central area in 2001 would have to be incressed by about a third - i.e. over 200 m.g.d. The programme depends upon maintaining proper standards of treatment for water taken into supply and on securing and maintaining tha wbolesomeness of those rivers from which the water is taken. Special responsibility rests on tbose

administering the Rivers (Prevention of Pollution) Acts 1951-1961 and on all authorities and industries discharging used water. The following factors make that responsibility more important than ever before:-

(1) local authority sewage works have nowadays to handle not only sewage from domestic properties but those industrial effluents which are accepted into the public sewers;

(2) a large volume of such effluents is also discharged directly to rivers;

(3) effluents now form a much higher proportion of the total flow in rivers such as the Thames, Lee and Great Ouse.

34. Continuing research will be needed into the nature of industrial effluents and the problems associated with controlling their discharge either to the public sewers or direct to rivers. Special attention will need to be given to toxic compounds, particularly those which are not easily removed or broken down. It may well become necessary to prescribe specific rules for dealing with industrial effluents according to the use made of the river into which they are discharged.

35. Ministerial responsibility for control of pollution rests with the Minister of Housing & Local Government and we feel it our duty to draw the attention of the Minister to the serious issues which are involved. In addition, local authorities responsible for effluent disposal must be made aware of their increasing responsibilities in this respect not only in controlling their own effluents and in supervising private discharges to public sewers but also in securing that arrangements for the treatment of effluents are made concurrently with development. We wish to emphasise that it is not just a matter of knowing how to treat effluents. Finance must be provided to build treatment plants and they must be built to keep pace with the increase in water supplies. It must be remembered that every additional million gallons of water put into supply means, broadly speaking, another million gallons of effluent to be treated.

36. The provision of water supplies is not the only reason for maintaining high water quality conditions in the rivers. The rivers themselves may, if polluted, become a danger to health, unsightly and offensive. Fish life may well disappear entirely, as it has in some of the rivers in the north of England. The maintenance of fish life is a matter to which we attach considerable importance, not only for the recreational facilities it provides, but as the best indicator we have at present of satisfactory water quality in our rivers.

Requirements of land

37. In our proposed programme, construction of big new surface storage reservoirs in the central area is envisaged only to supplement or to follow the development of the ground-water resources and, with the exception of one major scheme for the Welland and Nene area, need not commence until after 1975. Indeed, our concern to keep to a minimum the demand upon agricultural land has been a major factor in shaping our recommendations with their provision for a reappraisal in the early 1970's. In the unlikely event of all the reservoirs listed in Appendix IV to the Committee's report being required, about 35,000 acres of land would be inundated. This is equivalent to an average annual loss of 1,000 acres over the 35 years to the end of the century. These are large acreages but we emphasise that we are not yet committed to requiring them.

Capital and other costs

38. No precise estimate can be made yet of the total investment required between now and the end of this century since a major re-assessment will be needed after completion of the surveys and investigations we recommend in this report. The Committee have, however, tried to estimate the cost of the schemes in their programme for meeting deficiencies up to 2001 with and without a Wash barrage. We think their figures, which are quoted below, are as good an estimate as can be made at present of the order of investment likely to be necessary:-

ESTIMATED CAPITAL COSTS EXCLUDING LOCAL DISTRIBUTION 1966-2001

(a) Central area

(1) Combination of inland schemes	-	£310 millions
or		
(2) Pattern incorporating Wash barrage	-	£400 millions

(b) Self-sufficient areas

(3) Probable combination of schemes listed in Appendix IV of the Committee's report	-	£100 millions

In addition, there will be expenditure on local distribution works. The Committee consider that this will total between £300 millions and £350 millions up to 2001 no matter what pattern of headworks emerges.

Overall, therefore, they envisage an investment of between £710 millions and £850 millions during the next 35 years.

39. Carrying out the programme outlined in this report and summarised in paragraphs 43 and 44 will also involve expenditure on surveys and investigations by river authorities, statutory water undertakings and ourselves over a period of years. Much of it will be a proper charge on capital account and is likely to be the subject of applications for loan sanctions. While we are mindful of the overriding need for economy in public expenditure we cannot overstress the importance of the programme of investigations and trust that all necessary monies and consents for it will be forthcoming.

Fisheries research

40. In paragraph 16 we suggest that in five river authority areas internal resources will be sufficient to meet growing demands. In two of these areas, namely the Hampshire and Avon and Dorset areas, the chalk rivers have so far been relatively little developed for water supply. Potentially there should be surplus resources available here but these rivers contain some of the country's finest fisheries whose water requirements the 1963 Act safe-guards. We need to know more about those requirements to arrive at estimates of the amount of water which can be brought into use without harm to fisheries, and we shall be pursuing these questions with the river authorities and other parties concerned.

Liaison with local planning authorities

41. In preparing estimates of future demands for water and in formulating proposals for augmenting supplies, whether by the development of aquifers or by surface storage or hy transfers from outside their areas, river authorities will need to maintain close liaison with local planning authorities. Indeed, without a full understanding of each other's problems and proposals, neither a river authority nor a local planning authority will be able to discharge their functions effectively. We trust that there will be the fullest possible messure of consultation and co-operation between them on all aspects of their work and between them and the Regional Economic Planning Councils and Boards.

Organisation

42. In paragraph 17 we stressed that we are faced with a regional problem going beyond the resources of any one water undertaking or river authority. The pattern of regional water supply outlined by the Committee and endorsed by us will require a regional network of aqueducta within the areas of five or six river authorities and many major water undertakings. The construction and operation of this network will require s high degree of co-ordination and may well involve setting up an ad hoc body under the Water Act 1945 and the Water Resources Act 1963. Clearly a Wash barrage would also involve special administrative arrangements. We shall be giving our attention to these problems. We do not foresee any insuperable difficulties in solving them, though they are likely to involve complicated financial arrangements with existing authorities.

Summary of recommendations for action

43. In the self-sufficient areas listed in paragraph 16 above, the river authorities should be able to meet their needs from resources in their own areas.

44. For the deficiency zone we have outlined in paragraphs 25 to 31 above a progressive programme of action covering both the construction of works to secure the position during the next decade and a series of investigations to he completed hy the early 1970's when a major re-appraissl will be needed. The following table summarises the programme of works and investigations which appear to us to be necesssry and about which we shall consult the river authorities and other hodies and interests concerned:-

PROGRAMME OF WORKS AND INVESTIGATIONS FOR THE CENTRAL AREA

A. Works to be completed as soon as possible

1. Expansion of Diddington scheme;

2. Construction of Datchet reservoir;

3. Intake on Ely Ouse and transfer of water to Essex;

4. Sunnymeads intake on River Thames;

5. Completion of Farmoor reservoir;

6. Local schemes in Essex and East Suffolk;

B. Works to be completed as required

7. Development of the ground-water resources in the Peterborough area and adjoining parts of the Lincolnshire River Authority area;

8. Manton or Empingbam reservoir (dependent upon outcome of site surveys and explorations - see 13 and 14 below);

C. Ground-water pilot schemes to be carried out as soon as possible

9. Lsmbourn scheme of the Thames Conservancy;

10. Psrallel scheme by tbe Great Ouse River Authority to establish feasibility of controlled development of the chalk aquifer;

D. Phased programme of surveys and explorations of reservoir sites

(a) by the end of 1967

11. Waddesdon;

12. Wbitchurch;

13. Manton;

14. Empingham;

15. Great Bradley;

(b) by tbe end of 1969

16. Cobbins Brook;

17. Abbotsley;

E. Investigations to be completed by tbe early 1970's

18. Wash Barrage: feasibility study;

19. Desslination: operational experience of large-scale plant in U.K. conditions;

20. Schemes whereby water could be transferred to the Thames area from other areas e.g. Severn, Avon and Dorset;

21. Problems arising in operating a regional delivery network.

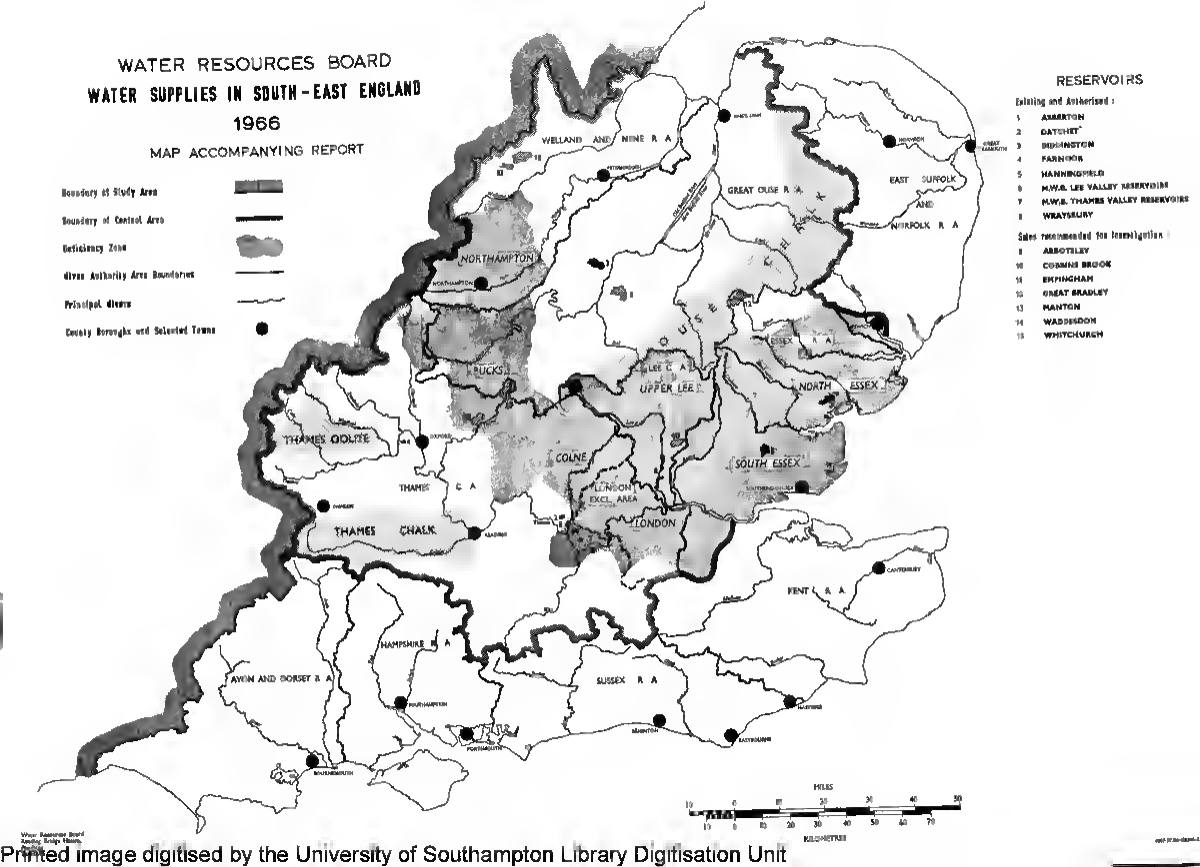
Need for frequent review of plans

45. Tbis report and the Committee's report have been produced as a matter of urgency in advance of the river authorities' statutory surveys under section 14 of the Water Resources Act 1963. From the licsnces of rigbt now being granted under Part IV of tbat Act we shall obtain for tbe first time detailed information about the present use of water by industry and agriculture and when the river authorities have completed their section 14 surveys we sball have s revised forecast for tbe future. Althougb we do not expect thsse figures to require major revisions in the programme outlined in this report, we would emphasise that planning of tbis sort is not a once and for all

operation. It must be repeatedly revised to take account of developments. But this does not affect the urgency of the present situation and the need for early action in the manner we have described. We conclude this report, therefore, hy conveying this sense of urgency not only to Ministers but to all concerned for without it future water supplies in the South East may well be in jeopardy.

Reading Bridge House
Reading
Berkshire

10th May 1966



REPORT OF THE TECHNICAL COMMITTEE

Members

B. Rydz Esq., B.Sc., Tech., M.I.C.E., M.I.W.E., F.A.S.C.E. (Chairman)	Water Resources Board
H. W. Clark Esq., A.M.I. Struct.E., M.I.W.E.	Welland and Nene River Authority
W. K. Masters Esq., M.A., A.M.I.C.E., A.R.I.C.S.	Great Ouse River Authority
K. E. Cotton Esq., M.B.E., M.I.Mun.E., M.R.S.H., M.Inst.H.E., M.I.W.E.	East Suffolk and Norfolk River Authority
E. L. Snell Esq., O.B.E., M.I.C.E., M.I.W.E.	Essex River Authority
N. Medrington Esq., A.M.I.C.E., M.I.W.E.	Lee Conservancy Catchment Board
Colonel H. C. Bowen, O.B.E., T.D., M.A., M.I.C.E., A.I.Mech.E., M.I.W.E.	Thames Conservancy
J. I. Taylor Esq., M.B.E., B.Sc., M.I.C.E., M.I.W.E.	Kent River Authority
C. H. H. Mercer Esq., B.Sc.(Eng), M.I.C.E., M.I.W.E., M.I.Mun.E.	Sussex River Authority
A. T. Macdonald Esq., B.Sc., M.I.C.E.	Hampshire River Authority
W. H. Crocker Esq., B.Sc., M.I.C.E., M.I.W.E.	Avon and Dorset River Authority
L. H. Brown Esq., B.Sc., M.I.C.E., M.I.W.E. Mid-Northamptonshire Water Board	British Waterworks Association, Eastern Regional Committee, Welland & Nene Area
J. W. Milne Esq., M.I.C.E., M.I.W.E. Lee Valley Water Co.	British Waterworks Association, Eastern Regional Committee, Great Ouse Area
J. L. Ringrose Esq., A.M.I.C.E., A.M.I.W.E. Ipswich County Borough Council	British Waterworks Association, Eastern Regional Committee, East Suffolk and Norfolk Area
P. Gordon Spencer Esq., B.Eng. M.I.C.E., M.I.W.E., A.M.I. Struct. E. M.A.S.C.E., F.G.S. South Essex Waterworks Co.	British Waterworks Association, Eastern Regional Committee, Essex Area
J. Christie Esq., B.Sc., M.I.C.E., M.I.W.E. Colne Valley Water Co.	British Waterworks Association, London & South Eastern Regional Committee, Lee Area
W. M. Lloyd Roberts Esq., M.Eng., M.I.C.E., M.I.W.E. Metropolitan Water Board	British Waterworks Asaociation, London and South Eastern Regional Committee
R. Pownall Esq., M.A., M.I.C.E., M.I.W.E. Bucks Water Board H. H. Crawley Esq., M.I.C.E., M.I.W.E. Oxford Corporation Waterworks	) British Waterworks Association,) London & South Eastern Regional) Committee, Thames Area

J. Leslie Unitt Esq., M.I.C.E., A.M.I.E.E., M.I.Mech.E., M.I.W.E., F.G.S. (to September 1965) Thanet Water Board	British Waterworks Association, London & South Eastern Regional Committee, Kent Area
W. H. Tripp Esq., M.A., A.M.I.C.E., A.M.I.W.E. (from September 1965) Medway Water Board	
F. Needham Green Esq., B.Sc.(Eng), A.C.G.I., M.I.C.E., A.M.I.W.E., A.M.I.Mech.E., F.G.S. Brighton Corporation Waterworks	British Waterworks Association, London & South Eastern Regional Committee, Sussex Area
C. A. Bradley Esq., B.Sc., M.I.C.E., A.M.I.Mech.E., M.I.W.E. Southampton Corporation Waterworks	British Waterworks Association, South Western Regional Committee, Hampshire Area
N. V. Martin Esq., Bournemouth & District Water Co.	British Waterworks Association, South Western Regional Committee, Avon & Dorset Area
Mrs. M. E. B. Cartwright (Secretary)	Water Resources Board

Observers

R. F. Gingell Esq., T.D., J.P. C. E. C. Townsend Esq., T.D., B.Sc.(Eng), M.I.C.E. J. H. Potter Esq., B.Sc. Tech. A.M.I.C.E., A.M.I.W.E.	Port of London Authority
E. F. F. W. Usher Esq., M.I.E.E., M.I.Mech.E. K. M. Gammon Esq., B.Sc., A.M.I.C.E.	Central Electricity Generating Board
J. W. M. Hawksworth Esq., M.I.C.E., F.G.S. M. W. Summers Esq., M.I.C.E., M.I.W.E. R. F. Caple Esq., A.M.I.C.E., M.I.Mun.E., A.M.T.P.I.	Ministry of Housing and Local Government
R. B. W. Bannerman Esq., B.Sc., M.I.C.E., M.I.W.E. H. P. Briggs Esq., D.L.C., A.M.I.C.E., M.I.W.E. Dr. J. Ineson, B.Sc., Ph.D., P.A.I.W.E., F.G.S. H. J. Richards Esq., B.Sc., P.A.I.W.E., F.G.S. R. G. Sharp Esq., B.Sc., M.I.C.E., M.I.W.E. L. E. Taylor Esq., B.Sc., D.I.C., A.M.I.C.E., A.M.I.W.E.	Water Resources Board

Deputies for Members

We are grateful to the undermentioned Engineers who have sat from time to time on the Committee as accredited deputies:

H. van Oosterom Esq., B.Sc., A.M.I.C.E., A.M.I.W.E.	Great Ouse River Authority
E. J. Brettell Esq., M.A., M.I.C.E., A.M.I.W.E.	Thames Conservancy
V. E. Brook Esq., A.M.I.C.E., A.M.I.W.E.	Sussex River Authority
E. B. Mohba Esq., A.M.I.C.E., A.M.I.Mun.E., A.M.I.Struct.E.	Hampshire River Authority
G. N. Hooper Esq., B.Sc., A.M.I.C.E., A.M.I.W.E. Metropolitan Water Board	British Waterworks Association London & South Eastern Regional Committee
L. F. Hobbs Esq., B.Sc., M.I.C.E., M.I.Mech.E. Rickmansworth & Uxbridge Valley Water Co.	British Waterworks Association, London & South Eastern Regional Committee, Lee Area
K. B. Clarke Esq., B.Sc.(Eng), A.M.I.C.E., A.M.I.W.E., M.R.S.H., F.G.S. East Anglian Water Co.	British Waterworks Association, London & South Eastern Regional Committee, East Suffolk & Norfolk Area
G. W. Fuller Esq., B.Sc., A.M.I.C.E., M.I.W.E. Oxford Corporation Waterworks	British Waterworks Association, London & South Eastern Regional Committee, Thames Area
E. R. Griffiths Esq., M.I.C.E., M.I.W.E. North West Sussex Water Board C. J. Mustchin Esq., M.I.Mun.E., M.I.W.E., M.R.S.H., F.G.S. Brighton Corporation Waterworks	British Waterworks Association, London & South Eastern Regional Committee, Sussex Area
L. J. Simpson Esq., M.I.C.E., M.I.W.E. G. Slater Esq., B.Eng., A.M.I.C.E., A.M.I.W.E. Portsmouth Water Co.	British Waterworks Association, South Western Regional Committee, Hampshire Area

CONTENTS

Ths Maps detailed below are contained in the separate Wallet attached.

Map 1: General Msp of Area

Map 2: Statutory Water Undertakings

Map 3: Estimated Total Demands of Statutory Water Undertskings for Distribution within each River Authority Area

Map 4: Water Supply Balance Related to Authorised Resources for Ststutory Water Undsrtakings in each River Authority Ares

Map 5: Sprsy Irrigation: Estimated Maximum Seasonal Demand in each River Authority Area

Map 6: Estimated Combined Effective Deficiencies of Statutory Water Undertakings, Industry and Agriculture in each River Authority Area

Map 7: Csntral Area, Deficiency Zone, and Location of Major Resourcss

REPORT TO WATER RESOURCES ROARD

PREFACE: APPOINTMENT AND PROCEDURE

1. Our terms of reference were as follows:

(a) to assess demands for water in south east England in the years up to 2001 for the following purposes:-

(i) puhlic water supply;

(ii) industrial uss over and ahove that ohtainsd from the public supply;

(iii) agricultural use;

(iv) maintenance of river flows etc.;

(b) to determine which sources were availshle to meet demands, indicating the advantages and disadvantages of each and placing them in order of prefsrence (hearing in mind all interests including land use and amenity) and to indicate the probable timetable for development;

(c) to consider the system hy which water would be distrihutsd in hulk, either raw or treated, to ths principal users in the area.

2. We have met on asven occasions. On the first four occasions the meetings were conducted in two groups, a northern group embracing the areas of the Welland and Nene, Great Ouse, East Suffolk and Norfolk and Esssx River Authorities together with the areas of the Lee Conservancy Catchment Board and of the Thames Conservancy, and a southern group embracing the area of the Thames Conservancy and those of the Kent, Sussex, Hampshire and Avon and Dorset River Authorities. Ths Committee mst as a single hody for its last three meetings.

3. We are grateful to our authorities for allowing us to ssrve on ths Committee and to the individual statutory water undertakings and other organisations not directly represented on the Committee who have gathered and presented information for the Committee's use.

4. The opinions sxpressed in this report do not necessarily represent the views of all the members of the Committee and cannot be taken as committing any authority to the course of action recommended by us in the report.

CHAPTER 1. INTRODUCTION

1.1 The South East Study

In February 1964 the Ministry of Housing and Local Government published the report* of a study of the problems which were expected to result from population growth in south east England in the period 1961-1981. The area studied (see Map 1) was defined by county boundaries and comprised the three standard census regions of south eastern England together with Dorset; it differed somewhat from the area of the present study. However, when considering water supplies, Northamptonshire, the Soke of Peterborough and Swindon were added to the Study area and Dorset (apart from Poole) was excluded. The report stated that within the 'Water Study' area - which also differed from the area of the present study - the population was likely to grow from 18 millions to 21½ millions over the period 1961-1981, the per capita consumption of water from statutory water undertakings in the area from 50.3 to 65 gallons per day, and the total demand on these undertakings from 909 to 1372 million gallons per day. The report briefly reviewed the possibilities of exploiting new resources in the region - particularly in the valleys of the Thames and Great Ouse - and of importing water to the Thames from the south and west.

It pointed out that the size and urgency of the water problems in the south east were such that a preliminary investigation of the possibilities of various major regional water schemes should be set on foot at once and suggested that this could be one of the first problems to which the Water Resources Board (which had not then been established) would wish to turn its attention.

1.2 Hydrological Surveys

The Ministry of Housing and Local Government have published in recent years a series of hydrological surveys of river basins, of which the following refer to parts of the present study area:-

River Great Ouse Basin (1960)
Essex Rivers and Stour (1961)
River Lee Basin (1962)
East Anglian Rivers (1963)
Kent Rivers (1964)
Welland and Nene Rivers (1964)

The physical and hydrological characteristics of each basin are set out in these surveys, together with schedules of water use and an outline of the possibilities of further water resource development. The proposals outlined were in many cases only tentative since data were not available to confirm their feasibility and probable cost and because consideration of such sources in the context of probable demand was beyond the scope of these surveys.

1.3 Water Resources Act 1963

Section 14 of this Act requires each river authority to carry out periodical surveys of the water resources of its area and of the probable demands on those resources. It will be a duty of each river authority to see that the development and control of resources keeps pace with requirements within its area. The Water Resources Board is obliged to see that appropriate steps are taken to re-distribute water from areas of surplus to areas of deficiency.

---

* *The South East Study, published by Her Majesty's Stationery Office in 1964.*

CHAPTER 1. INTRODUCTION

1.1 The South East Study

In February 1964 the Ministry of Housing and Local Government published the report* of a study of the problems which were expected to result from population growth in south east England in the period 1961-1981. The area studied (see Map 1) was defined by county boundaries and comprised the three standard census regions of south eastern England together with Dorset; it differed somewhat from the area of the present study. However, when considering water supplies, Northamptonshire, the Soke of Peterborough and Swindon were added to the Study area and Dorset (apart from Poole) was excluded. The report stated that within the 'Water Study' area - which also differed from the area of the present study - the population was likely to grow from 18 millions to 21½ millions over the period 1961-1981, the per capita consumption of water from statutory water undertakings in the area from 50.3 to 65 gallons per day, and the total demand on these undertakings from 909 to 1372 million gallons per day. The report briefly reviewed the possibilities of exploiting new resources in the region - particularly in the valleys of the Thames and Great Ouse - and of importing water to the Thames from the south and west.

It pointed out that the size and urgency of the water problems in the south east were such that a preliminary investigation of the possibilities of various major regional water schemes should be set on foot at once and suggested that this could be one of the first problems to which the Water Resources Board (which had not then been established) would wish to turn its attention.

1.2 Hydrological Surveys

The Ministry of Housing and Local Government have published in recent years a series of hydrological surveys of river basins, of which the following refer to parts of the present study area:-

River Great Ouse Basin (1960)
Essex Rivers and Stour (1961)
River Lee Basin (1962)
East Anglian Rivers (1963)
Kent Rivers (1964)
Welland and Nene Rivers (1964)

The physical and hydrological characteristics of each basin are set out in these surveys, together with schedules of water use and an outline of the possibilities of further water resource development. The proposals outlined were in many cases only tentative since data were not available to confirm their feasibility and probable cost and because consideration of such sources in the context of probable demand was beyond the scope of these surveys.

1.3 Water Resources Act 1963

Section 14 of this Act requires each river authority to carry out periodical surveys of the water resources of its area and of the probable demands on those resources. It will be a duty of each river authority to see that the development and control of resources keeps pace with requirements within its area. The Water Resources Board is obliged to see that appropriate steps are taken to re-distribute water from areas of surplus to areas of deficiency.

---

* *The South East Study, published by Her Majesty's Stationery Office in 1964.*

It will be aome time, however, before tbe initial surveys can be completed by river authorities. In one instance - the Great Ouse area - a survey along similar lines was commissioned in 1964 by the Ministry of Housing and Local Government from a firm of consulting engineers, Messra. Binnie and Partners, and the Committee have made use of the findinga of that report*.

1.4 The Present Stndy

Because of the urgent need to develop new sources of supply for parts of south aast England and because of the evident interdependence of river authority areas in this region, aarly guidance on the proper regional pattern of water development was essential. The Water Resources Board therefora convened two meetings early in February 1965 with the Acting Clerks and Chief Engineers of each of the river authorities in the south aast, officers of the Thames Conservancy and the Lee Conservancy Catchment Board, and representatives of the corresponding regional organisations of the British Waterworks Association. At those meetings it waa decided to set up two Tecbnical Committees to review as quickly as poasible the probable growth of demand in the aouth east and to conaider the best way of deploying the region's resources to meet this demand.

The terms of reference of the study, which are set out in full in the preface, covered the assessment of water demand for all foreseeahle purposes in south east England during the remainder of thia century, comparison of availahle resources, and consideration of the probable timetahle of development of resources and of the system of bulk distrihution of water within the region.

To some extent the work of these Committees must anticipate the findinga of the periodical surveys required to be carried out hy river authorities under section 14 of the 1963 Act: becausa of this the data assemhled by us relate to river authority areas, the hasic units for future water resource development. The area studied (deacribed bereinafter as the southb east region) is shown in relation to the South Eaat Study and South Eaat Water Study areas in Map 1, and comprises the eight river authority areas shown below together with the London Excluded Area and the areas of the Thames Conaervancy and Lee Conservancy Catchment Board.

Welland and Nene
Great Ouae
East Suffolk and Norfolk
Essex

Kent
Sussex
Hampshire
Avon and Dorset

1.5 Organisation of Study:

It was agreed at the meetings held in Fehruary that in view of the size and complexity of tbe south east region, the problems of water demands and rasourcas sbould be considered in two hroad zones - a northern zona embracing tbe areas of the Welland and Nene, Great Ouse, East Suffolk and Norfolk and Essex River Authorities together with the areas of the Lee Conservancy Catchment Board/ and of the Tbames Conservancy/, and a southarn zona emhracing the area of the Thames Conservancy/ and those of the Kent, Sussex, Hampshire and Avon and Dorset River Authorities.

** The Report on the Water Resources of the Great Ouse Basin (availeble from the Ministry of Housing and Local Government - price nine guinees).*

/ Referred to in later paragraphe of this report under the generic title 'river authority'.

The study was therefore conducted initially by two Technical Committees representing the northern and southern zones respectively. Each Committee comprised the chief engineers of each river authority in the zone and the engineers representing the B W.A. regional organisation for each river autbority area, together with a representative of the B.W.A. London and South Eastern Regional Committee, with the Chief Engineer (Planning) of the Water Resources Board as chairman. Continuity between the two Technical Committees was maintained by representation on both of the Thames Conservancy and the B.W.A. London and South Eastern Regional Committee. Members of both Technical Committees attended the last three meetings which were conducted as joint meetings. Meetings were also attended by technical observers from the Ministry of Housing and Local Government, the Central Electricity Generating Board and the Port of London Authority.

These meetings have served as a forum for discussion between engineers of statutory water undertakings, which have hitherto alone exercised responsibility in the field of water conservation, and engineers of the river authorities, which henceforth will be increasingly concerned with the problems of resources and demands under the new legislation. Close co-operation between these bodies will be vital and has been much in evidence at meetings of the two Committees.

1.6 General Situation

The south east region extends over about 19,000 square miles. Its mean annual rainfall averages about 27 inches and if we deduct a mean annual evaporation of 18 inches, there remains a residue (referred to as 'run-off' in subsequent paragraphs of this report) which averages about 9 inches per annum over the region but which varies from less than 4 inches over much of Essex to over 20 inches in parts of Dorset. This annual run-off is equivalent to about 6,500 million gallons per day (m.g.d.) on average, but the rate of run-off is very variable and only by the development of storage can a substantial fraction of it be made available for continuous use.

The population of about 19 millions receives supplies from statutory water undertakings (referred to subsequently as 'public water supplies') totalling just over 1,000 m.g.d. (53 gallons per head per day (g.h.d.)). Other supplies (including cooling water at power stations and water for irrigation) total about 750 m.g.d. on average so that the total amount taken into use averages about 1,750 m.g.d.

CHAPTER 2. DEMANDS AND RESOURCES OF STATUTORY WATER UNDERTAKINGS

2.1 Present Demands

Water is supplied to consumers in the south east region by 131 statutory water undertakings, whose limits of supply are shown in Map 2. The undertakings are listed in Table I of Appendix I for each river authority area, the estimated mean daily quantity supplied during 1964 being given in the Table. It should be noted that undertakings which overlap the boundaries of river authority areas are taken into account in two or more of those areas as appropriate, the estimated demand within each particular river authority area being quoted.

Analysis by the Ministry of Housing and Local Government of some fifty representative undertakings in the region, accounting for about 90 per cent of the total consumption, revealed that metered supplies comprise about 33 per cent of the total public water supplies.

2.2 Estimation of Future Demands

The population of the south east region is expected to increase considerably as a result of both natural growth and immigration from other regions, and consumption per capita may be expected to keep on increasing. Future demand can only be assessed by extrapolating previous growth trends in some way - either by extrapolating the trend of overall use, by combining expected population growth with trends in per capita consumption or by using the one process for metered use and the other for unmetered use. Each of these has its advocates. We have had considerable discussion on the merits of these methods and also on the probable causes of recent increases in per capita use.

The analysis by the Ministry of Housing and Local Government referred to above and appended as Appendix II suggested that the combined metered and unmetered consumption might be represented by a trend zone from about 50 gallons per head per day in 1965 to between 55 and 64 g.h.d. in 1981 and between 62 and 88 g.h.d. at the end of the century. In the South East Study a minimum figure of 65 g.h.d. in 1981 was suggested whilst the authors of the Report on the Water Resources of the Great Ouse Basin adopted figures of 65 g.h.d. in 1981 and 80 g.h.d. in 2000 (excepting for new town developments for which a figure 10 per cent higher was used.)

Estimates of future population in each river authority area have been supplied by the Ministry of Housing and Local Government and these are given in Table A. Some statutory water undertakings have made their own estimates or have obtained estimates from local planning authorities. Some of these estimates differ materially from those given in Table A. For instance, the future population in the Great Ouse area as estimated by statutory water undertakings in the area is considerably greater: this arises principally on account of the estimates submitted by the Bucks Water Board who have expressed the view that the Table A figure is an underestimate. On the other hand, the Ministry's population estimate for Hampshire for the year 2001 considerably exceeds the local estimate. We have thought it better to quote the Ministry's estimates in this report since we are most concerned with the population growth in the region as a whole.

We have not attempted to impose uniformity of approach on the demand figures submitted by individual undertakings. Many are based on the application to expected population totals of per capita consumptions of 65 g.p.d. (in 1981) and 80 g.p.d. (in 2001), whereas others (e.g. Metropolitan Water Board) are based on trends of total consumption. Some areas with higher per capita figures have allowed for a shift of industrial consumption from private

TABLE A

ESTIMATED POPULATIONS, DEMANDS AND IMPLIED PER CAPITA USE
IN RIVER AUTHORITY AREAS

River Authority Area	1964			1971			1981			2001		
	Population Thousands	Average Daily Demand m.g.	Per capita use g.p.d.	Population Thousands	Average Daily Demand m.g.	Per capita use g.p.d.	Population Thousands	Average Daily Demand m.g.	Per capita use g.p.d.	Population Thousands	Average Daily Demand m.g.	Per capita use g.p.d.
Welland and Nene	630	29	46	720	41	57	910	74	81	1,270	119	94
Great Ouse	960	49	51	1,120	71	63	1,310	107	82	1,900	171	90
East Suffolk and Norfolk	770	31	40	820	40	49	930	56	60	1,210	92	76
Essex	1,910	90	47	2,070	121	58	2,250	154	69	2,820	222	79
Lee, Thames and (i) London excluded area	10,440	585	56	10,910	665	61	11,540	785	68	13,570	1,010	74
Kent	1,730	86	50	1,890	110	58	2,080	141	68	2,730	209	77
Sussex	1,000	50	50	1,070	61	57	1,130	76	67	1,340	105	78
Hampshire (ii)	1,020	65	64	1,160	90	78	1,370	122	89	2,110	194	92
Avon and Dorset	640	36	56	700	47	67	770	60	78	990	95	96
Total/Mean	19,100	1,021	53	20,460	1,246	61	22,290	1,575	71	27,940	2,217	80

NOTES: (i) *In this table only, the Lee Conservancy area has been combined with the Thames Conservancy and the London Excluded Area because of uncertainties over the distribution of population between the Lee and London areas.*

(ii) *The relatively high per capita figures for the Hampshire area are largely due to the allowance for bulk supplies to Fawley Oil Refinery.*

to public water supplies and some boliday areas obtain high per capita figures by dividing annual average demand over the resident population. The future demand for Bucka Water Board (Great Ouse and Thames areas) has been calculated as the product of estimated population and estimated per capita use and in suhstituting reduced figurea for estimated population we have alao auhstituted reduced figures for their estimated total demand.

The assumad overall growth of demand for the south east region during 1964 to 2001 corresponda to an average annual growth rate of 3.1 per cent of the 1964 figure (i.e. aa simple interest growth). For comparison, the 1964 damands given in Table A represent a simple interest growth rate of about 3.5 per cent per annum over the 1955 demands quoted in the First Report* of the Central Advisory Water Committee's Sub-Committee on the Growing Demand for Water, although average increases of only 1.5, 0.7 and 1.0 per cent per annum were forecast in that report for the Eastern, London and South Eastern and Southern Administrative Regions, respectively, for the period 1955-65.

It should be appreciated that estimates of future consumption are at hest representative of a hroad trend of possible growth and that the level of demand predicted for a remote future data may be reached many years before or after that date. We feel, however, that the demands which we have allowed for at the end of the century should be regarded as the loweat figures which are likely to apply at that date unlass the population forecasts prove radically wrong. Our forecasts for 1981 are designed to ensure that adequate resources will be daveloped by that date by putting in hand suitable works during the next dacade. The 2001 figures, on the other hand, are such as should avoid risk of abortive expenditure in preparing for conditions at that remote date.

2.3 Tabulated Demands

Table I (Appendix I) shows for each river authority area in the region estimated future demand figures for each undertaking, or part of an undertaking, in the years 1971, 1981 and 2001 and the total for each river authority area. The figures quoted in the Table have been calculated from average annual demands.

The comparativa size of demand and rate of growth of demand in eech river authority area is illustrated diagrammatically in Map 3.

2.4 Existing Resources

For the purposes of this report we have defined the 'yield' of existing sources of supply (underground and surface) as the average annual demand which could be met continuously from the present installetions, bearing in mind the fluctuation of demand which characterises the locality. This achieves consistency with the use of average annual demand figures in all areas, whatever the type of source.

2.5 Further Authorised Resources

These are resources (yield defined as in 2.4) for which undertakings have all the necessary powers to acquire land, abstract water and construct works. They include such major schemes as the Diddington scheme of the Great Ouse Water Authority, the Wraysbury end Datchet Reservoirs of the Metropolitan Water Board and the Farmoor scheme of Oxford Corporation as well as many small schemes, totalling some 200 m.g.d. of yield in the south east region.

---

* *Published by Her Majesty's Stationery Office in 1959.*

or the 'downstream' deficiency (whichever is the greater) need be met hy new resources, provided, as discussed just previously, that these new resources supply the necessary supplement to river flows during critical periods. The 'upstream' deficiency exceeds the 'downstream' deficiency throughout the period under consideration, and the excess can be considered available (following its 'upstream' use) for export to other river basins.

For the Great Ouse we have taken into account future increases in the yield of the Diddington Reservoir as calculated in the Report on the Water Resources of the Great Ouse Basin; these increases were computed by assuming a 90 per cent return to the river of additional water required in the future hy consumers upstream. The apparent area deficiency has been reduced accordingly, on the assumption that this increased yield can be applied against specific deficiencies shown in the Table.

3.4 Water Quality

The re-abstraction of increasing amounts of sewage effluents in this way may be a matter of some concern in the future although little is yet known about the hazards, if any, involved. It is for this reason that we have not taken advantage of the full possibilities of successive re-use on the Thames upstream of Teddington - as we might have done by covering only the smaller 'downstream' deficiencies - hut have instead suggested that all deficiencies of the 'upstream' users be made good independently. In respect of the Lee, although considerable extra yields (over 30 m.g.d. in 2001) could he obtained hy re-abstraction of new effluents arising over the period of study we have, for the purposes of this report, assumed that they will not be taken into public water supply. The possibility of further re-use in the Lee should, however, be borne in mind for the future.

Opportunities for re-use of water may also occur elsewhere - for instance, in the Essex rivers and in the River Nene. Unless effluents are to be deliberately piped hack for supply - and this would raise quality prohlems requiring careful examination - the amounts involved are not likely to he substantial. No account has therefore been taken of augmentation of resources by this means except in the Rivers Thames and Great Ouse referred to above.

As has been pointed out in the Report on the Water Resources of the Great Ouse Basin and elsewhere, several of the rivers of south east England may consist substantially of sewage effluent during future dry summers and a steady improvement in the general standard of the effluents discharged will he essential.

3.5 Effective Deficiencies

By applying the above corrections, we have drawn up a Table of 'effective deficiencies' of public water supplies in each river authority area (Appendix I). These effective deficiencies (disregarding any unused surpluses and any outstanding export liabilities, such as those from the Thames to South Essex) have been abstracted to the Summary Table (Appendix I). The figures in the last line of the Table represent the amounts which have to be made available at points of use throughout the region by new schemes of water supply or by works to transfer surpluses from one undertaking to another.

For convenience, we have reproduced the effective deficiencies in the following Table B which also shows the authorised resources in each area.

TABLE B

EFFECTIVE INTERNAL DEFICIENCIES OF RIVER AUTHORITY AREAS

(PUBLIC WATER SUPPLIES ONLY)

River Authority Area	Authorised Resources m.g.d.	Estimated Effective Deficiencies (to nearest 5 m.g.d.) (From Summary Table, Appendix I)		
		1971	1981	2001
Welland and Nene	32	–	30	75
Great Ouse	99	15	30	65
East Suffolk and Norfolk	62	–	10	30
Essex	74	30	80	150
Lee	103	–	20	85
Thames (Including London Excluded Area)	580	10	55	185
Kent	138	5	20	85
Sussex	66	5	10	35
Hampshire	65	10	45	115
Avon and Dorset	75	–	5	35
Totals	1,294	75	305	860

NOTE: The Thames deficiencies reflect the requirements of users whose consumption would be returned as effluent above Teddington Weir; these exceed the corresponding deficiencies below the Weir and the excess (approximately 35 m.g.d. in 1981 and 135 m.g.d. in 2001) would be available for export re-use. The total deficiencies given in the table exceed the totals required from new conservation works by these amounts.

Map 4 shows diagrammatically the data contained in Appendix I. The basic unit on the map is a double-column block drawn to a convenient vertical scale. The left hand column shows the authorised internal resources and, where appropriate, an 'apparent deficiency'; the right hand column represents the estimated internal demands and, where appropriate, an 'apparent surplus' which brings the two columns into balance (see Table I, Appendix I). There are three of these blocks representing the public water supply balance for the years 1971, 1981 and 2001 in each river authority area.

The 'apparent deficiency' is represented by imports to the area (if any) plus the effective deficiency which has to be made good and, for the Thames and Great Ouse areas, a re-use allowance which indicates the assumed augmentation of resources in the area by the re-use of effluents discharged to rivers. The 'apparent surplus' in the right hand column is made up of local surplus resources which may or may not be transferable to offset deficiencies in the area or elsewhere (see 6.1). As explained above, the method of allowing for re-use in the Thames area means that a further surplus is available for export at Teddington, being the difference between the 'effective deficiency' supplement and the actual re-use indicated for users in the Thames Conservancy and London Excluded Areas.

CHAPTER 4. DIRECT INDUSTRIAL DEMAND

4.1 Basis of Estimates of Present Demand

We are concerned here with the demands which privately and publicly owned industry (other than public water supply and agriculture) might wish to meet from private sources of supply.

Information on past and present industrial use is only fragmentary. The Sub-Committee on the Growing Demand for Water analysed data obtained from six major water-consuming industries and published in their First Report estimates of the demands of these six industries, together with the nationalised industries, for 1955. They assumed a 25 per cent increase by 1965. From those estimates, we have assessed the figures representing the area of the present study as:-

1955 : 280 m.g.d.

1965 : 350 m.g.d.

The Sub-Committee's figures included only the net use of cooling water by the Central Electricity Generating Board (i.e. the evaporative loss in recirculatory cooling systems) but it would appear that they took into account the gross demand of other industries. Thus they included use of water for through-cooling which could be reduced by the adoption of recirculatory systems. They did not, however, purport to cover the whole of industry. The Sub-Committee suggested multiplying the demand figures by a factor of 0.8 to allow for successive re-use but there is little doubt that this understated the possibilities for successive re-use by industries in some inland areas.

The Hydrological Surveys published by the Ministry of Housing and Local Government (see 1.2) incorporate schedules of users and summaries of industrial abstraction, effluent discharge to rivers and to the sea and apparent net losses, and these have provided useful guidance. However, although a distinction is drawn in these Surveys between public water supply sources and industrial supplies obtained from private sources, and between effluents discharged privately to streams and those discharged from public sewage works, it cannot be assumed that private supplies are inveriably linked to private disposal arrangements and so no clear picture of net use emerges.

We have obtained information for some areas by direct enquiries to industry and in due course much more complete information will be obtainable by analysis of applications for licences under Part IV of the 1963 Act. Some assessment of the probability of net use of water by industry may also be made by theoretical calculations (e.g. for heat dissipation at power stations), bearing in mind that there are few industries which evaporate or otherwise consume appreciable quantities of water at inland sites or which divert water out of inland waters for appreciable distances.

4.2 Future Net Private Industrial Demand

We consider here the demands of privately owned industry separately from those of the Central Electricity Generating Board. Only those new net demands which may arise in the future are thought to be directly relevant to this study. We have attempted to assess present net demand from the information described above and to apply an appropriate growth rate to determine future net demand.

Evidence on the rate of growtb of private abstraction is scanty. Annual rates of growth varying from 2 per cent of tbe present figure to 4 per cent compound bave been put forward, the latter rate being based on the national productivity expansion rate adopted by the National Economic Development Council. In some areas growth pro rata with population change has been proposed whereas in others reductions in direct industrial use bave been visualised. Such estimates as bave been made refer to gross use: similar rates of growth may not be applicable to net use.

The growth rate of metered supplies by statutory water undertakers offers some guide to changes in industrial use. Its relevance may be obscured, however, by a shift of industrial demand to or from public water supplies. The 1963 Act enables industry to develop private supplies with greater security than hitherto and it can be argued that this will lead to greater reliance on private supplies, especially where water of lower quality than that supplied by public water undertakings is acceptable. Nevertheless, we feel that on balance the trend will be the other way: i.e. towards increasing reliance by industry on public water supplies, and we have set the future per capita demand on public water supplies at a high figure in some areas where extensive new development is contemplated, in order to allow for this.

The Ministry of Housing and Local Government analysis (Appendix II) indicates an average growth of about 3 per cent per annum of the 1946 metered supply per capita in the six selected areas over the period 1946-64; the overall metered growth is, however, obscured by regroupings of major undertakings with smaller undertakings whose records have been less complete. In Essex the total metered supply appears to have increased during this period by something like 6½ per cent per annum (simple).

There is clearly no reliable guide at present to the rate of growth of net private industrial demand. Table C includes our estimates of present gross and net use by private industry and our proposed allowances for future net use. These are based generally on an assumed growth rate of 4 per cent per annum of present net use but with modifications in areas where the present net use appears to be negligible, where especially high per capita figures have been allowed for future public water supply or where present net use is thought to be unduly high in relation to gross use.

4.3 Central Electricity Generating Board

The south east region accounts for some 40 per cent of the present electricity demand in England and Wales and is expected in the 1980's to have a demand twice as large as the 1960 demand for England and Wales. This vast increase must be met by building new power stations.

To continue meeting new demands largely from outside the region, (as has been done over the last 15 years) would mean increasingly severe technical, economic and amenity problems. Not only are there few suitable coal-fired power station sites remaining on the Midland coalfields, but to connect these by additional high voltage overhead transmission lines to the load centres in the south east must make considerable impact on local amenity. Generation from coal will also be less economical than from oil or nuclear energy.

We are advised by representatives of the Central Electricity Generating Board that it is impracticable to concentrate new power stations on the coast within the south east region partly because their construction on suitable undeveloped sites would often conflict with other interests and partly because they would be remote from major load centres west of London, involving long transmission lines. The 1963 Act offers new opportunities for obtaining water supplies inland and transferring water to sites near load centres away

from the water source. This would facilitate the development of new power stations inland in the south east region.

The 2000 MW capacity stations now coming into operation circulate, when on full load, over 50 million gallons of water an hour for cooling purposes. Where the water source is insufficient to allow a once through system - direct cooling - the water is re-used after losing heat to the atmosphere in cooling towers. Under average conditions of temperature and humidity, 1 per cent of the quantity circulated is evaporated, i.e. up to 14 m.g.d.

The gross abstraction for tower-cooled power stations is required to make up evaporative losses and 'purge' from the cooling water system which keeps concentration of salts and impurities in the circulated water to an acceptable level. The quantity purged from the system varies: where there is a very soft pure water source it may be less than the amount evaporated; but where very hard waters are used it may be up to four or five times that amount. Assuming reasonable water quality and economy in use at a power station the average amount abstracted would be made up equally of evaporation and 'purge' water, i.e. gross abstraction would be twice the net.

On the national electrical system the average annual load factor approaches 50 per cent. The pattern of national demand for cooling water corresponds to the demand for electricity i.e. as an approximate guide the average daily evaporation for modern plant operating with cooling towers is 3½ mg/1000 MW. The operation of an individual power station may vary widely daily, seasonally and over its life. Generally, power stations are operated to a higher capacity in winter and are used less and less as they become older. This can result in a reduction in the gross abstraction of water from a river as older stations, operating on direct cooling, are less used because new larger stations, with cooling towers, take over the load; the net abstraction however, increases because of evaporation losses.

It is not at present envisaged that dry cooling towers, which do not have evaporative losses, will be economic where water is available at reasonable prices.

The Central Electricity Generating Board have supplied us with approximate figures of the non-saline cooling water now used in the region and with estimates of their planned use in 1970. They have also supplied their tentative forecast of requirements in 1981 and 2001 but they have emphasised that predictions about cooling water demand or even about the methods of power production at these future dates are speculative in the extreme.

Table C has been prepared from these estimates and those referred to in 4.2. Both gross and net figures of industrial use are given for 1965, but only the estimated net figures are given for future years. The figures included for the Central Electricity Generating Board represent the probable combined evaporative use at power stations in average conditions and are lower than the peak demand for water used at power stations when each is new and on full load. The required intake to a station would be approximately twice the evaporative use, which means that each must have access to a watercourse or aqueduct conveying that amount. For instance, a 2000 Megawatt station, at full output, would probably require a feed of at least 30 m.g.d., of which 14 m.g.d. would be evaporated and the remainder would be discharged with approximately double the input concentration of dissolved solids. The 'purge' must be carried away from the cooling system but may be suitable for other uses. Some further comments on the siting of power stations appear in 8.7.

TABLE C

ESTIMATED DIRECT INDUSTRIAL DEMAND

River Authority Area	Average Daily Demand – m.g.d.						Net Deficiencies – m.g.d.		
	Gross Use 1965		Net Use including C.E.G.B.						
	Excluding C.E.G.B.	C.E.G.B.	1965	1971	1981	2001	1971	1981	2001
Welland and Nene *	19	80	14	17	21	35	3	7	21
Great Ouse	35	60	12	15	36 (16)	74 (44)	3	24	62
East Suffolk and Norfolk	15	20	5	7	10	15	2	5	10
Essex	38	–	19	24	31	45	5	12	26
Lee	33	90	11	14	26 (8)	35 (8)	3	15	24
(Thames	50	120	5	10 (3)	30 (20)	63 (48)	5	25	58
(London Excluded Area	30	–	30	30	30	30	–	–	–
Kent	80	–	60	64	70	80	4	10	20
Sussex	4	–	2	2	3	4	–	1	2
Hampshire	8	–	5	5	6	7	–	1	2
Avon and Dorset	4	–	2	2	3	4	–	1	2
Total Industrial Demands	316	370	165	190 (3)	266 (44)	392 (100)			
	686								
Total Industrial Net Deficiencies							(to nearest 5 m.g.d.) 25	100	225

NOTES: *Figures in brackets indicate demands by the Central Electricity Generating Board which have been included in tabulated figures; the allocation between Thames, Lee and Great Ouse must be regarded as flexible.*

* *Including Corby and District Water Co. (Stewarts and Lloyds).*

4.4 Public Water Supply and Direct Industrial Deficiencies

The future effective deficiencies for public water supplies (Table B) and the net industrial deficiencies (Table C) calculated above are brought together in Table D. It should be noted that much of the water provided from new sources for public water supplies will in fact be available for subsequent re-use by industry, either by abstraction from inland waters or, in some localities, by the direct use of treated sewage effluent, so that the future industrial water use allowed for is in effect considerably greater than shown in Table C.

TABLE D

FUTURE EFFECTIVE DEFICIENCIES

PUBLIC WATER SUPPLIES AND DIRECT INDUSTRIAL DEMANDS

River Authority Area	Total deficiencies (to nearest 5 m.g.d.)		
	1971 m.g.d.	1981 m.g.d.	2001 m.g.d.
Welland and Nene	5	35	95
Great Ouse	20	55	125
East Suffolk and Norfolk	5	15	40
Essex	35	90	175
Lee	5	35	110
Thames (including London Excluded Area)	15	80	245
Kent	10	30	105
Sussex	5	10	40
Hampshire	10	45	115
Avon and Dorset	–	10	40
Totals – to nearest 100 m.g.d.	100	400	1,100

NOTE. The Thames deficiencies reflect the requirements of users whose consumption would be returned as effluent above Teddington Weir; these exceed the corresponding deficiencies below the Weir and the excess (approximately 35 m.g.d. in 1981 and 135 m.g.d. in 2001) would be available for export re-use. The total deficiencies given in the Table exceed the totals required from new conservation works by these amounts.

CHAPTER 5. AGRICULTURAL DEMAND

5.1 Characteristics of Demand

Agricultural demand falls into two general classes: that for spray irrigation and that for stock watering, washing, milk cooling and other general farm uses. We are advised that there is not expected to be any substantial increase in the latter type of demand on either public water supplies or private sources. We have assumed that such increases as will occur will be covered by the general allowances for increased public water supplies and no separate consideration is therefore given to them in this report.

The demand for water for spray irrigation differs somewhat from the demands for public water supply and industry because it is more sensitive to availability and cost of water. The economic limits of irrigation use for particular crops are not easy to predict, especially for remote future years. The relevant factors are outlined in various publications of the Ministry of Agriculture, Fisheries and Food and in the Report on the Water Resources of the Great Ouse Basin (Volume I, Appendix III). For the purposes of this report, however, it has been decided to consider the demand in two broad divisions, viz: that for 'low value crops' (principally grassland and sugar beet) and that for 'high value crops' (the remaining irrigable crops - principally potatoes, vegetables and orchard fruit). Although storage of water for irrigating grassland has been provided by farmers in some localities and a case may be made for irrigating a proportion of the grassland area in this way, we have assumed that, in general, the low value crops will make an effective demand only in so far as water is available for abstraction directly from inland waters during the irrigation season, without conservation works, but that the high value demand will justify expenditure on conservation works, groundwater abstraction and, where necessary, the import of water from other river authority areas.

5.2 Methods of Supply

(i) Direct abstraction from a nearby inland water for spraying on to crops is the cheapest and most common form of irrigation; with this form of irrigation the cost of application is likely to outweigh abstraction charges by a considerable margin in most places. Future availability of water for this purpose will depend upon dry weather flows, the minimum acceptable flows determined by river authorities and the needs of existing lawful abstractors; but in certain areas it may be possible to sustain increasing acreages of 'summer irrigation' - i.e. irrigation supported by abstraction during the growing season - as sewage effluents contribute increasingly towards dry weather flows.

(ii) Irrigation with water taken from boreholes, in general, is the next cheapest form of irrigation. In so far as it diminishes dry weather flows in inland waters it ranks as 'summer irrigation', but the impact on those inland waters may be delayed sufficiently for the effect to be that of a winter abstraction. In localities where abstraction of ground water equals or exceeds the average net percolation no further licences for borehole irrigation will be permissible in any event.

(iii) Water may be abstracted from inland waters (or boreholes) in winter and stored in reservoirs for summer use or use may be made of ground-water storage by depleting the ground-water reserve and providing 'compensation boreholes' to maintain stream flows in dry weather. Storage of surplus flow in local farm reservoirs appears to be more economic and convenient for irrigation than major public conservation works but where water is not available

or suitable conditions do not obtain for local reservoirs, 'public' conservation works with distribution by pipeline or river may provide a viable alternative for high value crops.

(iv) There are other forms of irrigation - release of water into ditches through 'slackers' in the Fens, sub-surface irrigation from ditches in the marsh areas of Kent and Sussex and flooding of water-meadows in the Avon and Dorset area - whose effect on resources is difficult to assess. These uses have been borne in mind, however, when estimating available resources in these areas.

5.3 Existing and Future Demands

Information on past and present acreages under irrigation in each river authority area has been obtained from the Ministry of Agriculture, Fisheries and Food./ The proportions of low value and high value crops have been estimated and the growth of each sector has been extrapolated to the end of this century. The projected total acreages at the latter date in general lie close to the ultimate acreages envisaged in the Report* by the Natural Resources (Technical) Committee.

Water demand in each area during a peak irrigation season has been assessed by assuming a seasonal use of 5 inches over the areas under irrigation with a peak daily use of 0.08 inches over the whole of these areas, in accordance with the recommendations of the Ministry. The present and projected acreages and the corresponding peak seasonal and daily demands are set out for each river authority area in Appendix III, most of them culminating in the 'ceiling' acreages envisaged for each area in the Report of the Natural Resources (Technical) Committee. The projected seasonal demand in each river authority area in 1965, 1971, 1981 and 2001 is indicated diagrammatically on Map 5 from data tabulated in Appendix III.

We must emphasise that future irrigation demands have been estimated by extrapolation from a very limited base period and are subject to unforeseeable economic and political influences. They must be regarded as speculative.

5.4 Effective Irrigation Demand

In assessing 'effective' irrigation demand in future years, we have discounted projected growth, in either high value or low value categories, beyond the 'ceilings' postulated in the Natural Resources (Technical) Committee Report, although in the view of certain members of the Committee growth beyond these 'ceilings' may well occur. The estimated future demand will be further restricted, in most areas, as a result of our assumption that irrigation of low value crops cannot justify expenditure on conservation works and will depend upon water available from natural summer flows.

The assessment of future availability of water for summer irrigation abstraction is a matter of some difficulty, especially where ground-water use may be involved. The critical factor is the demand made in dry weather during the peak of the growing season - generally in July - and unless emergency restrictions on abstraction are to be imposed by river authorities the peak daily rate to satisfy deficiencies must be available in all years. This is of the order of 1.8 m.g.d. per 1000 irrigated acres. The licensing of irrigation use in wetter summers over and above that which can be maintained in critical conditions is not considered in this report, as its profitability is dubious. River authorities will have to assess from time to time the water

---

/ *In the cases of the Welland and Nene, Essex and Avon and Dorset River Authorities, however, present use has been derived from analysis of licences.*

* *'Irrigation in Great Britain', published by Her Majesty's Stationery Office in 1962.*

available for abstraction in summer in the light of any minimum acceptable flows which they may determine. In this report we have divided areas into the following groups:

(i) Areas with Dry Weather Flow Available for Abstraction:

Avon and Dorset

Hampshire

Large parts of these areas are drained by rivers with well-maintained summer flows and are underlain by aquifers. High value crops occupy a comparatively small sector of the total irrigable acreage. We expect that this sector of demand and much of the remainder will be met by the issue of licences for summer abstraction. The whole of the projected irrigation demand is regarded as an 'effective demand' in this report subject to the Ministry of Agriculture, Fisheries and Food's limit of ultimate growth. It is of little relevance to the water resources balance of the rest of the region, however, although it might somewhat reduce the export possibilities which are outlined in Chapter 7.

(ii) Areas Without Dry Weather Flow Available for Abstraction

(a) Thames

Although much of the Thames area resembles the Avon and Dorset and Hampshire areas, little or no dry weather flow is available for additional abstraction because of the requirements of downstream users. Although water can probably be put into the river system at a very low average cost from the proposed Thames ground-water controlled abstraction scheme, (Thames 17 in Appendix IV) the amount needed for peak daily demand would call for a large number of extra boreholes or substantial local storage and it is doubtful if grassland irrigators would find it worthwhile to pay for either. Only the high value crop demand (about a half of the whole) has been regarded as an effective additional demand in future and it is assumed that the effective demand will be met from local storage works without prejudicing the yields of major conservation schemes. However, a conservative limit of yield has been taken for the ground-water controlled abstraction scheme and if conservation in the Thames is based on that scheme it is possible that further yield would be available and could be used to meet the remainder of the projected irrigation demand.

(b) Great Ouse

Welland and Nene

The irrigation prospects of the Great Ouse area were examined in some detail in the Report on the Water Resources of the Great Ouse Basin. It seems that the dry weather resources of much of the area are already over committed to licensees of right but towards the end of the period under review it may be possible for further summer abstraction to be licensed as more effluents will then be discharged into the upper reaches of the Bedford Ouse. The assumed effective demand is therefore represented by the high value demand plus the low value demand covered by licences of right, disregarding supplementary low value demand which might be met without storage in later years. The irrigation deficiency is represented by the excess of the effective demand over the available dry weather resources. This deficiency must be met by local farm

storage or alternatively must be set against the export possibilities of major surface or ground-water storage schemes in the area.

Similarly, in the Welland and Nene area there will be little scope for further direct abstraction of surface water for spray irrigation in dry weather, although the matter is complicated by the practice hitherto of diverting Nene flow into the catchment of the Great Ouse for the maintenance of water levels in the Fens. The effective demand has been assessed in the same way as for the Great Ouse area, and must be met by provision of local farm storage or by diversion from major surface storage schemes.

Existing irrigation in the Fens by 'slacker' abstraction from rivers is not included in the data tabulated in Appendix III. We have assumed that in the South Level of the Fens this type of abstraction uses up to 37 m.g.d. of river flow in dry summer weather and that it will continue unchanged. Allowance has been made for this in assessing the available resources of the area. Existing irrigation demand in the Middle Level of the Fens is known to be in excess of the dry weather resources of that area. We consider that this demand must be met principally by the further conservation of Great Ouse water as the diversion of water from the River Nene downstream of Peterborough, as practised hitherto, will be the subject of review to accord with the commitments and requirements of the Welland and Nene River Authority.

It is assumed that in the Great Ouse and Welland and Nene areas the effective demand will be met from local storage works without significantly diminishing the conservative yields claimed for major conservation schemes in Appendix IV.

(c) East Suffolk and Norfolk

Kent

Sussex

We consider that in these three areas little further direct abstraction from inland waters for spray irrigation is likely to be permitted and that there may be localities where licence of right abstractions will overtax the dry weather flows. Extension of irrigation by surface water is likely to depend upon the provision of more local farm storage. Some additional direct ground-water abstraction will be possible in these areas and river regulation by controlled ground-water use may support further abstraction, particularly in Norfolk. We have assumed that the effective demand in these three areas will be made up of the estimated present demand plus future demands for high value crops only, and that these demands will be met from the internal resources of the respective areas, without significantly affecting the estimated yields of schemes listed in Appendix IV.

Sub-surface irrigation in the marsh areas of Kent and Sussex has not been included in the tabulated data in Appendix III. These uses will doubtless be taken into account when the minimum acceptable flows of the inland waters in these areas are determined.

(d) Essex

Lee

These two areas have virtually no water available for the extension of irrigation. We have assumed that the effective demand will be made

up of the present demand plus future demands for high value crops only and that these effective demands will have to be met by imports into these areas.

Table E shows the assumed effective demands in millions of gallons per peak irrigation season for each river authority area, these assumed effective demands being indicated by heavy broken lines on Map 5.

TABLE E

SPRAY IRRIGATION

ASSUMED EFFECTIVE PEAK SEASONAL DEMAND

River Authority Area	Millions of gallons			
	(to nearest 100 m.g.)			(to nearest 500 m.g.)
	1965	1971	1981	2001
Welland and Nene	600	800	1,200	2,000
Great Ouse	4,300	6,300	8,400	10,000
East Suffolk and Norfolk	3,200	3,900	4,700	5,000
Essex	1,700	2,200	2,800	3,000
Lee	400	500	800	1,000
Thames *	1,800	2,300	2,600	3,000
Kent	2,300	3,000	4,200	6,000
Suasex *	700	1,000	1,000	1,000
Hampshire	400	700	1,000	1,500
Avon and Dorset	1,500	1,800	1,900	2,000
Totals (to nearest thousand m.g.)	17,000	23,000	29,000	35,000

** These two areas are in a marginal category and it is possible that considerable additional acreages of grassland will be irrigated and the figures of future irrigation use correspondingly increased.*

This total peak seasonal demand may be converted into the following approximate values of equivalent daily demand. All figures in m.g.d. to nearest 10 m.g.d.

	1965	1971	1981	2001
(1) Long term average use	40	50	60	70
(2) Average day of year of peak demand	50	60	80	100
(3) Average day during peak irrigation season (150 days)	110	150	190	230
(4) Peak rate of daily use	270	370	460	560

5.5 Significant Irrigstion Deficiencies

We have assumed that the effective irrigation demands listed for the Hampahire and Avon and Dorsat areas in Table E will be met substantially by direct summer ahstraction, altbough in a few localities in those areas there will he deficiencies to bs made good by conservation works. In the remaining areas part of the demand is now met by direct abstraction snd further direct abstraction may be licensed in the future. Since the dry weather resources of some of these areas are alresdy over committed, however, and soms conservation works may be necessary to maka good already inadaquate atraamflows in drought conditions, we consider that, having regard to our terms of referance (a)-(iv), the whole of their listed effectivs demands should be treated as irrigation deficiencies. In most cases, this necessarily ovsrstatss requirements. Such deficiencies - amounting to about 90 per cent of the region's irrigation demand - muat be made good hy public or private conservation works.

These irrigation deficiancies, together witb the estimated deficiencies for public water supply and industry, ara shown diagrammatically in Map 6. The irrigation deficiencies of significance for ths main conclusions of this report are tboss in the Essex and Lee areas, which, if they are to be met, necessitate imports, snd thosa in the Thames and Graat Ouse araas, whicb might impinge on resources which could otherwise be exportsd.

The irrigstion demand, being intermittent and very variable, cannot readily be compared with the continuous demands for domestic and industrial uae refsrred to in previous chapters. Various daily equivalents of the irrigation demand are given in Tahle E; none of these is precisely comparable with continuous demands. The peak daily usa is significant for borehols or pipaline capacity, unless surface storage is added; the seasonal use or long-term avarage use may govern a storage scheme, depending on the storage available. It is shown in The Report on tha Water Resources of ths Great Ouse Basin that for typical impounding or pumped storage surface reservoirs the irrigation use figure whicb may be compared directly with reliahle continuous yield lies hetween the values sbown in lines (2) and (3) in Table E (average day of year of paak demand and average day during pesk irrigation sesson).

For simplicity, the irrigation deficiencies are exprassed in terms of the equivalent daily use in a year of peak demand i.e. as the maximum sessonal deficiencies divided by 365. Those for the Essex and Lee areas are assumed to require an equivalent daily import, a peak aeason's uss being made good by uniform daily increments into storage during the ensuing year. The Thsmes area deficiency is likely to he met from local storage works and horehols (and perhaps partly from the proposed Thames ground-water controlled abstrsction scheme) without materially affecting present abstractors. The Great Ouse area deficiency can be made good partly by local storage reservoirs which are not listed in the proposed new rasources of the area (Appendix IV) and partly at the expense of schemes which are so listed. However, the yields which we have assigned to those schemes in this report are conservative and allow for considerable sbstraction to farm storage. It seems reasonable to assume, therefore, thst the Great Ouse area irrigstion deficiency will not impinge materially on the estimated yields of conservation projacts listed in Appendix IV for that area.

The irrigation deficiencies which we have taken into account in considering the overall halanca of surplus and deficiency areas ara shown in Table F.

TABLE F

REQUIRED IMPORTS

m.g.d.

River Authority Area	1971	1981	2001
Essex) Lee)	7	10	11

It should he noted, however, that the storage (private and public) required throughout the region to meet the maximum seasonal demand listed in Table E will amount to some 30,000 million gallons in the year 2001, including storage in the Essex and Lee areas to accommodate the above imports which we have assumed will arrive in uniform daily increments throughout the year. It is likely that most of this storage will be in the form of small farm reservoirs.

CHAPTER 6. PROPOSED PUBLIC RESOURCES

6.1 Transfer of Surpluses

We have considered the suhstantial surpluses which are shown in the Tables of Appendix I to see how they may be utilised before looking for new resources. Many of them ere not transferable to meet deficiencies elsewhere because they are too small and remote or hecause the surplus is too short-lived for any transfer to be economic. In general, only those which erise from storage schemes are of significance in the overall resources balance and these can be applied, at least in part, against deficiencies elsewhere.

The important surpluses in this category are those of the Metropolitan Water Board and the Oxford Corporation in the Thames area and those of the constituent undertakings of the Great Ouse Water Authority (the Mid-Northamptonshire, Nene and Ouse, North-Bedfordshire and Mid-Bedfordshire Water Boards and the Luton and Lee Valley Water Companies) in the Great Ouse ares.

The Metropolitan Water Board and most of the Great Ouse Water Authority surpluses sre earmarked for transfer to those parts of the undertakings which are in other river authority arees, and are shown es imports into those areas. However, provided that the authorised works of the Great Oise Water Authority ars completed before 1971 the Authority is likely to have an overall surplus of about twslve m.g.d. at thst dste and should he eble to spare enough water to meet the deficiencies of the Bucks Water Board from 1969 until 1972, with a diminishing contribution for about two years theresfter. By 1974 the authorised rssourcss are likely to be fully taken up by the six constitusnt undertakings of the Authority.

The Oxford Corporation surpluses would arise from the expedited completion of that undertaking's Farmoor scheme. Although they would not necessarily be completely transferable outside the Thames area, an arrangement to expedite completion of stage II of the Farmoor schsme for river regulation purposes would belp to meet the deficiencies of the Colne Valley and Rickmansworth and Uxbridge Valley Water Compenies in the early 1970's if no better solution to that problem presents itself.

It may well be that certain other transfers can be effected between undertakings locally to meet short-term needs in the less needy areas (for example, East Suffolk and Norfolk and the south coast areas) but tbese would be of marginal significance in the context of this report.

6.2 Information on New Sources

Information on sources which have bsen proposed for development has heen supplied to the Committee jointly by the river authority engineer and ths B.W.A. representative for each area. The proposals range from schsmes which water undertakings have had under consideration and which, in some cases, have been thoroughly investigated, to ideas which have been briefly referred to in Hydrological Surveys (Ministry of Housing and Local Government) and which have received little critical attention. In all casea the suggested available yields will be subject to ths determinations hy rivsr euthorities of minimum acceptable flows for the inland waters concsrned and to the licensing conditions which they will prescribe.

The proposals which have been referred to the Committee ere tabulatsd in Appendix IV by river authority areas and for each area an attempt has been made to group the schemes into the following categories:-

(i) Schemes specific to immediate local needs (generally less than 5 m.g.d. yield)

These are sources (mainly boreholes) which would meet local deficiencies in public water supplies and hence would reduce the accumulated deficiencies listed for certain areas but which have no other relevance to the regional study. Their inclusion in the tables means that, in the opinion of the Committee there is a prima facie case for further investigation or development but, with a few exceptions, no further comment on the merits of individual proposals will he made in this report.

(ii) Major schemes for supply within river authority area

These are more substantial schemes which, although they may have been proposed for a particular statutory water undertaking, are here considered against the overall requirements of a river authority area. Some of them, because they would be unusually costly or for other reasons, must stand comparison with possible alternative supplies from regional schemes.

(iii) Regional schemes

These are general schemes (or important units of such schemes) of ground or surface water development for a river authority area which are designed to relieve public water supply, industrial or agricultural deficiencies throughout the area and/or to make water available for export to other areas for these purposes. This report is essentially concerned with the relative merits of these schemes for supplying areas of general deficiency.

(iv) Barrages

Several proposals for tidal barrages have been mooted from time to time and those which have been referred to the Committee are listed in Appendix IV. So far as we are aware the only one which has recently received even a preliminary engineering evaluation is that for The Wash. None of the schemes is of proved feasibility.

6.3 Costs of Water

Schemes in each of the first three categories (6.2) have been classified broadly in terms of unit water cost, which gives an indication of those schemes deserving priority on a cost basis. The costs quoted are the estimated costs per thousand gallons of treated water stored in service reservoirs, but excluding the costs of detail distribution, general overheads and local authority rates. A representative cost for present supplies in each area is quoted in Appendix IV for comparison. In general, where small local deficiencies are involved the costs of local ground-water sources cannot be challenged by those of water from regional schemes.

Most of the schemes in the second and third categories seem likely to provide water at a cost of about 30 pence per thousand gallons. Where the estimated cost of water from new surface storage schemes is considerably in excess of 36 pence per thousand gallons there is an incentive to look to regional schemes for an alternative supply. For some areas of deficiency, a closer comparison of the costs of supply from various sources is made in Chapter 8.

6.4 Selection of Schemes

In addition to cost, the following considerations need to be weighed in choosing between alternative schemes:

(i) Location

Other things being equal (including adequate supervision of treatment plant etc.) a source near to the demand is to be preferred to a more distant one.

(ii) Conveyance

If storage is to be exploited, schemes for river regulation and for conveyance of stored water in a river generally offer more economic use of storage and more benefit to other river users than schemes for direct supply through aqueducts and for bulk storage close to the consumer. This does not necessarily justify the use of a distant source in preference to a local one.

(iii) Land Use

Strong objection is usually made to the use of land for reservoirs. Provided that appropriate allowance is made for land purchase and for compensation - and we would draw attention to the remark made about this on pages 13 and 14 of the Second Annual Report of the Water Resources Board* - we do not accept the argument that it is wrong in principle to use land for reservoirs. Nevertheless, we recognise that objections on these grounds can be a serious impediment to the development of needed supplies and this strengthens the case for proposals which seem more likely to escape these objections. Indications of the quality of agricultural land involved and of other relevant aspects are given in the list of schemes in Appendix IV.

(iv) Amenity

Surface storage schemes can often add to rather than detract from general amenities, and the benefit arising from a well-designed reservoir, especially one affording recreational facilities, should be considered when schemes are planned. Moreover, regulating reservoirs which are used to augment the dry weather flows of a polluted river can do much to improve amenity along the entire course of the river.

6.5 Required Investigations

Most of the schemes listed in Appendix IV require preliminary investigation of some kind, e.g. pumping tests, site investigations and flow gaugings. The schemes involving controlled ground-water abstraction depend on much more extensive development work and at this stage their estimated yields cannot he relied upon to the same extent as those for the more conventional sources. It is highly desirable, therefore, that the appropriate investigations be put in hand at an early date. It may also be necessary to fall back on more

---

'The objections which are commonly made to [surface] storage appear to have little force in economic terms, since any loss in agricultural production could be made good many-fold by the diversion of a fraction of the stored water to irrigation. They appear to arise mainly from dissatisfaction with the compensation terms for tenant farmers and on amenity grounds.'

** Published by Her Majesty's Stationery Office in 1965.*

conventional schemes if the ultimate development of these schemes is slowar than we anticipate.

The tidal barrage schemes would also require considerable investigation to prove their feasibility and they can only he regarded as possihle sources in the latter part of the period under review.

6.6 Areas of Deficiency

We have compared demands (Table D) with potential resources (Appendix IV) and it is clear that the Essex, Lee and, possibly, Welland and Nene areas lack the internal resources to match their future needs. The deficiencias in these araas will probably have to be made good by imports from the adjoining Thsmes and Great Ouse areas which are conveniently placed to help. Map 6 shows the total effective deficiencies estimated for each area - i.e. the requirements for public watar supply (Chapter 3), industry (Chapter 4) and agriculture (Chapter 5) which must he met by new conservation works - and also indicates the three deficiency areas and the two areaa of potential surplus referred to above.

The remsining river authority areas appear to have potential resourcas adequate for thair needs over the period of review although there are parts of these areas - south east Suffolk and north west Kent - which are not well placed to take advsntage of the future internal resources suggested for their respective areas. Subatantial deficiancies will also occur in the moat westerly part of the Great Ouse area and at the eaatern end of the Thames area.

There is thus a 'deficiency zone' extending in an arc along the boundary of the Thames and Great Ouse aress from Northamptonshire through the London Basin and across Essex. It is with the needs of this zone and the selection of sources to satisfy these naeds that this report is most concarned. The extent of the zone and the location of the principal regional sources (Appendix IV, Category (iii)) are shown on Msp 7, in which the zone is divided into Sactions with representative delivery centres for comparison of costs. Category (ii) sources are indicated on this map hy reference to the numbers allotted to them in Appendix IV.

The balance of rasources within aach area is dealt with in Chapter 7 and the comparison of alternative regional resources in Chapter 8.

6.7 Special and Extra Regional Resources

Reference is mada here to certain possible resources other than those listed in Appendix IV. None of them would play a part in the pattarn of devalopment as we foresee it during the next decade hut one or more of them may be of relevance in the long term and appropriate studies should go forward.

(i) Imports from the west

Water may be pumped into tha uppar Thames from the Severn or possibly from the Wye. Conservation works would probably have to be undertaken in the source catchments but it is outside our terms of reference to examine in any detail the problems of siting, transfer or water quality. Howaver, the possible cost of water from these sources vis-a-vis water made available by regulation works in the Thames basin is referred to in Chapter 8. They will evidently deserve consideration should thera he difficulty in implementing the Thsmes ground-water regulation or surfsce storage schemes; they may also he required to provide additional sources in the last decade of this century. The prohlems should ba fully investigated.

The River Trent might provide an alternative route by which water from the west could he brought into the south east region as tbat river will be carrying increasing quantities of effluent resulting from water imported into the west Midlands and possibly water produced by further development of the River Derwent. Part of this could be piped into the Welland and Nene area if, in due course, the quality of the River Trent could be sufficiently improved.

If a Wash storage project was authorised, water from the River Trent could be fed into storage via the River Witham, subject to the gradient available on that river.

(ii) Wash Reservoir

A preliminary appraisal of a scheme for freshwater storage in the Wash is contained in the Report on the Water Resources of the Great Ouse Basin. Such a scheme would involve two or three river authority areas. It was recommended in that Report that a feasibility investigation and cost estimate of the Wash barrage should be proceeded witb.

Whilst it appears unlikely that water from such a source would be competitive in cost with, or of aa good quality as, water from other sources outlined botb in that Report and in Appendix IV, we nevertheless consider that an investigation should be made.

In Chapter 8 the Wash scheme is compared with a succession of inland developments throughout the region.

(iii) Artificial recharge of the London Basin

The Metropolitan Water Board have shown in the lower Lee valley that tbe chalk can be successfully recharged artificially with fully treated water (see 7.5, Lee). Research is required to show the minimum acceptable quality of the recharge water and more hydro-geological knowledge is needed before artificial recharge could be practised on a large scale in the London Basin. For theae reasons and because of the large quantities of water required for recharge before incressed abstraction could be authorised on a wide basia, tbe project must be regarded as a long term one, but it is being studied by the Water Resources Board.

(iv) Desalination

The present stage of development and the coats of production of desalted water do not make it a serious competitor with tbe schemes liated in Appendix IV. It may find application to meet acute summer peaks of demand in one or two coastal areas and there may be useful opportunities for pilot works in such places, but we cannot envisage its playing a major part in meeting tbe requirements of the region before 1981. Developments in technique or changes in fuel cost may alter the picture and it will of course be necessary to keep the possibilitiea of desalination under continuous review.

(v) Recovery and Processing of Sewage Effluents

In 4.4 reference was made to the supply of sewage effluents for industrial use, with or without further treatment. This could make substantial amounts of water available for industry in some coastal localities, particularly along the Thames estuary. In the more

important inland areas (Thames and Great Ouse) we have already taken available effluents into account by making allowance for successive re-use of river water, and direct feeding of effluents to industry in those areas would make little difference in quantitative terms to the amount of water available.

Further investigation should be made into the physical and administrative factors which might inhibit the re-use of effluents for industry as the (possibly successive) re-use of effluents from tidal outfalls would greatly increase the amount of water available for industry in the region and might render superfluous much of the allowance we have made for additional water for industry (Table C).

CHAPTER 7. BALANCE OF RESOURCES BY RIVER AUTHORITY AREAS

In this Chapter we consider the individual balance of each area but in Chapter 8 many of the areas are grouped together for a regional analysis, with the result that some of the internal arrangements suggested in this Chapter need modification to fit into the regional pattern.

For each river authority area we have compiled a table showing the combined effective deficiencies in m.g.d. to be made good by conservation works in the area or by import from other areas. The figures included in the tables have been derived from:

Public Water Supply	- Appendix I	(pages 79 to 91)
Industry	- Table C	(page 18)
Irrigation	- Table E	(page 25)

The categories and schemes for proposed sources referred to in this Chapter are taken from Appendix IV.

7.1 Welland and Nene

Combined Effective Deficiencies

Year	Public Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	-	3	2	5
1981	30	7	3	40
2001	75	21	4	100

We have assumed that the irrigation deficiencies will be made good by private storage works (see 5.4(ii)(b)).

There seems to be every likelihood that ground-water sources in the northern part of the area, perhaps supplemented by imports from Lincolnshire, will provide a further 15 m.g.d. and that this will suffice to meet the needs of the area (excluding the Mid-Northamptonshire and Wisbech undertakings) until about 1981. Thereafter, reliance will have to be placed on water available from surface sources in the area or on imports from the Great Ouse area.

We have assumed that the needs of the Wisbech area will be met by continued imports of water from the Great Ouse area.

A major pumped storage scheme (scheme 10) has been suggested to meet future requirements of the Mid-Northamptonshire Water Board area. Geological investigation of this scheme is in hand. The scheme envisages two pumped storage reservoirs at Empingham and Manton with connected intakes on the Rivers Nene and Welland. The combined yield of the two reservoirs is estimated at more than 50 m.g.d. It might be possible to increase the yield of the scheme by a further 6 m.g.d. by the construction of a third reservoir.

After allowing for its import of 12 m.g.d. from the Great Ouse area, the Mid-Northamptonshire Water Board will have deficiencies of about 20 m.g.d. in 1981 and 46 m.g.d. in 2001. We have assumed that scheme 10 will meet these deficiencies. In the year 2001 the overall needs of south Northamptonshire (including industry) may exceed the water available from this scheme, and supplementary water could perhaps be transferred from the Trent or the Great

Ouse areas. We bave assumed (see Chapter 8) that this supplementsry water will be obtained from the Great Ouse area.

7.2 Great Ouse

Combined Effective Deficiencies

Year	Puhlic Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	15	3	17	35
1981	30	24	23	75
2001	65	62	27	155

We have assumed that the irrigation deficiencies need not be met from the schsmes for new resources listed in Appendix IV. (See 5.4(ii)(h) and 5.5).

The schemes listed in Appendix IV have heen regrouped below. We consider tbat, having regard to the extent of preparatory and engineering work, the estimatsd costa in relstion to the henefits provided, and the likely ohstaclss to development, the major conservation schemes listed under (c), (d) and (e) helow sbould he tackled in that genersl order.

(s) (1-10) Local horeholes with estimated yields totalling about 14 m.g.d.

(h) (11) This scheme to abstract 6 m.g.d. from tbe River Wissy, (like a similar scheme for power station ahstraction nesr Denver) would use the capecity of the flood relief channel as halancing storage. Despite this storage, we bave assumed that the yield, like the yields for schemes 1-10, would not be additional to the estimated yield of the ground-water storage scheme 18.

(12) We have assumed that this scheme, whicb is based on hrickpit storage, would not add materially to the yield of scheme 17, should the latter bs developed. It might prove a worthwhile initial development, particularly for power station uss, if stabilisation of the pit sides did not involve excessive costs, but we do not consider that it would make any significant contribution to the overall watsr balance if the major scbemes listed for the Great Ouse area were to bs realised.

(c) (13 & 15) These two schemes relate respectively to the ahstraction via a new intake helow the sxisting intake on the Bedford hranch of the River Ouse, so as to increase the rsliahle yield of Diddington Reservoir (Grafham Water) by ahout 15 m.g.d., and the intermittsnt ahstraction from the River Ely Ouse or its trihutaries, without impinging on dry weather flows, for discharge into the Rivers Stour and Blackwatsr, so as to increase the reliahle yields of the Abberton and Hanningfield Rsservoirs in Essex hy about 22 m.g.d.

(d) (18) Stage I of this scheme provides for the controlled exploitation of ground-water storage in the chalk of the Ely Ouse catchment so as to obtain a continuous yisld of 80 m.g.d. for 'export' from the catchment, having first provided for the continuation of 'slacker' irrigation in the South Level of the Fens and guaranteed

a continuous flow of not less than 70 m.g.d. into the tidal Ouse at Denver Sluice. This would fully exploit the percolation income of the chalk (scheme 18(a)), but the artificial rechargs of surplus winter run-off into the chalk (scheme 18(h)), or other means of regulating and using this run-off, would possibly increase the export yield to about 125 m.g.d. (stage II). The demands of statutory water undertakings within the Ely Ouse catchment could be met hy intercepting part of the water destined to maintain the flow at Denver Sluics, and so would not impings on ths export yisld. We have assumed that schems 18(a), if it proves practicabls, can be completed by 1981 and schems 18(h) by 1990. It is aasumed that the yields claimed for schsmes 1-11 would bs merged in the yield of scheme 18.

The scheme would be based on a pattern of horeholes ('supply boreholes') covering the unexploited areas of chalk and giving a continuous yield (80 m.g.d. in stage I) for supply to consumers outside the catchmsnt. This would depress the water table during prolonged dry periods, so making storsgs available to accommodate subssquent percolation. An additional set of boreholes ('compensation horeholss') would therefore be necessary to maintain river flows during dry weather, and some of these could be used to afford a continuous supply to consumers within ths catchment bsfore discharge to ths rivers.

If the yield of the 'supply horeholes' could be collected by pipeline directly to treatment works and thence into supply, the above would probahly he the most economical arrangement. However, sincs it is proposssd that much of this water be conveyed into Essex and othsr areas in rivers (subsequently requiring full trsatment) it might prove mors expedient to discharge it first into the trihutariss of ths Ely Ouse and subsequently to abstract it into pipelines in the neighhourhood of (say) Ely for pumping over the watsrshed. By permitting aome regulation of dirsct run-off, this arrangement might render the recharge stage (stage II) unnecessary.

(e) (14, 16 & 17) These thres proposals for pumped storags ressrvoirs could yield 120 m.g.d. in 1981. Subssquent incresses in yield (from incrsased dry weather flow of effluents in streams) have been ignored in this report (see 5.5). The yields and the engineering works of schemes 13 and 15 would he msrged in thoss of schemes 14 and 16, rsspectively. Comhinsd with scheme 18(a) (controlled ground-water developmsnt) schemes 14, 16 and 17 would give a yield of about 185 m.g.d., as well as mseting additional needs within the Ely Ouse catchment.

These thres proposssd pumpsd storage reservoirs are:

(i) near Abbotsley in Huntingdonshire, to hold about 13,000 million gallons of water (14). It could be filled partly from a local intake from Brownshill Staunch (scheme 13) which would be used initially for supplying more water to Diddington Rsservoir.

(ii) near Grest Bradley in ths headwaters of the River Stour (16). It would hold about 13,000 million gallons and would be filled by pipeline from the Ely branch of ths River Great Ouse, ths pipelins being that initially used for putting Ely Ouss watsr into Essex rivers (scheme 15) and on the same route as any pipeline for picking up the yield of the controlled groundwater scheme (18(a)). The reservoir would be on glacial clay overlying chalk. Ths provision of Grsat Bradley Reservoir to

accommodate surplus run-off into the Ely Ouse may be regarded as an alternative to a recharge stage of the ground-water scheme (18(b)).

(iii) on the Kimmeridge clay, near Whitchurch in Buckinghamshire, holding possibly about 18,000 million gallons (17). It could be filled by a pipeline from the Bedford branch of the River Great Ouse near Newport Pagnell or, alternatively, from the River Thames near Renley, in which case its capacity might be made somewhat greater (depending on investigation of this site and the nearby site at Waddesdon).

It should be noted that the capacities and yields quoted for schemes 14, 16 and 17 (pumped storage reservoirs) are subject to site investigation and that the development of scheme 18 (controlled ground-water development) must be preceded by a programme of experimental field work to demonstrate the practicability of this form of ground-wster management.

1971: Part of the total deficiency of about 20 m.g.d. may be met by authorisation of local boreholes, although it may be necessary in some cases to make licences conditional upon provisions to maintain dry weather flows. The supply of water from the River Wissey to King's Lynn (scheme 11) would impinge upon dry weather flows at Denver Sluice which are required, inter alia, for the dilution of crude sewage discharged by King's Lynn Borough Council; improved arrangements for sewsge disposal might therefore facilitate the provision of this water.

The authorised works of the Great Ouse Water Authority will have a surplus yield of sbout 12 m.g.d. snd this, together with the completion of the new intake to Diddington (13), will enahle that Authority to meet the needs of the Bucks Water Board, ss well as those of their own constituent undertakings, until 1974 or 1975.

Completion of scbeme 15 (Ely Ouse water to Essex) would make about 22 m.g.d. of wster available in Essex, provided that the necessary work to receive and distribute this water is carried out.

1981: The internal deficiencies to be met amount to ahout 55 m.g.d: rougbly 25 m.g.d. in the catchment of the Bedford Ouse, 10 m.g.d. in that of the Ely Ouse and the remainder in the tidal Ouse area.

Scheme 13 will contribute ahout 15 m.g.d. in the catchment of the Bedford Ouse.

On the assumption that scheme 18(a) will he successfully completed by 1981 it will cover requirements in the Ely Ouse area as well as making sbout 80 m.g.d. available for supply to other parts of the Great Ouse area. 20 m.g.d. of this could be used to supply the tidal area and 10 m.g.d. could be transferred, via the Old West River and the Brownshill intake, to Diddington. A balance of ahout 50 m.g.d. would remain for export.

Scheme 15 would continue to make about 22 m.g.d. available in Essex, making ahout 70 m.g.d. in all available for export. A larger surplus could perhaps be developed in 1981, if required, by completing one or more of the reservoir schemes (14, 16 or 17) by that date. However, if the ground-water scheme cannot he developed as completely or as rapidly as we have assumed, it may prove necessary to construct one or more of these pumped storage reservoirs before 1981 in order to meet essential needs.

2001: The internal deficiencies to be met amount to about 125 m.g.d.

By making use of ths winter run-off (hy storage in Great Bradley Reservoir, hy recharge into tbe chalk or hy adapting scheme 18(a) as a regulating scheme), the yield of new schemes in tbe catchment of the Ely Ouse could be increased to ahout 125 m.g.d., in addition to meeting deficiencies (ahout 30 m.g.d.) in the Ely Ouse area. We think it prudent to assume that the 22 m.g.d. from scheme 15 would he ahsorhed in this total. This 125 m.g.d. would cover deficiencies in the area of the tidal Ouse and leave a surplus of about 85 m.g.d. available for export.

Schemes 14 (Ahhotsley Ressrvoir) and 17 (Whitchurch Reservoir) in the catchment of the Bedford Ouse would yield ahout 60 m.g.d., including the extra yield provided earlier hy schems 13. This would approximately halance the deficiency in the western half of the Great Ouse area.

In general, the yields of the schemes listed could be deployed in either the eastern or western parts of the Great Ouse ares, or in any of the adjoining deficiency sreas, without undue expenditure on capitsl works; howevsr, arrangements permitting substantial exports to the Essex area (including part of East Suffolk) seem to commend themselves on grounds of convenience and need.

The resources created by a harrage across the Wash and the general deployment of Great Ouse resources vis-a-vis Thames resources are considered in Chapter 8.

7.3 East Suffolk and Norfolk

Comhined Effective Deficiencies

Year	Puhlic Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	2	2	11	15
1981	9	5	13	25
2001	32	10	14	55

The local borehole schemes listed are estimated to yield over 6 m.g.d. and river regulation from horeholes is estimated to yisld a further 24 m.g.d. Here, as elsewhsre, proposals to regulate rivers hy intermittent pumping of horeholes must be suhject to investigation; the proposals may be regarded in effect as an extension of the chalk storage scheme (18) proposed for the Great Ouse area. Howsver, the supply required in Esst Suffolk and Norfolk is small in relation to the availahle run-off of the area and thsre is little doubt that the deficiencies of the greater part of the area (including hoth irrigstion deficiencies and thoss arising from the increased demands on the Norwich and East Anglian undertakings) can be made good hy such schemss together, psrhaps, with local surface storage schemss for irrigation.

No comment can bs mads on the feasihility of the Bure barrage scheme at the present time hut if this should proceed for land drainage purposes it might be desirahle to inveatigate the possihility of water conservation at the same tims.

The Ipswicb and soutb east Suffolk area requires separate appraisal. A scheme (7) is under consideration for a pumped storage ressrvoir at Washbrook which would meet the estimatsd demands of the Ipawicb area until about 1981 and, prima facie, deserves further investigation. Ths acheme entails abstraction from tbs River Gipping just upstresm from the tidal limit at Ipswicb, and delivery into a storage ressrvoir on the Bslstead Brook, a tributary of the River Gipping whose confluencs witb tbat river is below the tidsl limit.

The Gipping valley is already fairly heavily developed by ground-water abstraction, and ths scbeme now suggssted would fully develop ths rsmaining run-off. The Washhrook site is on the claysy tertiary deposits with overlying gravel and alluvium in tbe valley bottom. It is thought that if fully developed tbe site could stors about 5,000 million gallons. Initially the yield would be about 7 m.g.d. but this could subsequsntly be increased by a second intake on tbe Rivsr Stour to hring in watsr derived from the Great Ouse area. Under these circumstancss devslopment of the full storage capacity of tbe site may he merited, but the proposal would require detailed considsration vis-a-vis the Great Bradley scheme (Great Ouse scheme 16) and other proposals for storing ths surplus run-off of the Ely Ouse catchmsnt.

If, on completion of investigations, it is found that scheme 7 (Waahbrook Rsservoir) can offer a reliabls supply at a price below 36 pence per tbousand gallons it would seem an appropriate aolution for the problsms of the Ipswicb area. Failing the construction of such a reservoir, it may he possibls to obtain a littls mors chalk water locally but the area would then have to look to an early development of the Great Ouss chalk storage scheme (Great Ouss scbeme 18) in the headwaters of the Rivers Little Ouse or Thet. The headwaters of the River Thet is one of tbe areas which hsve been suggested for pilot schemes in tbe chalk and carsful considsration should be given to the possibilities of early assistance to the Gipping vallsy area from ths pilot instsllations.

7.4 Essex

Combined Effective Dsficiencies

Year	Public Wstsr Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	31	5	6	40
1981	80	12	8	100
2001	148	26	8	180

The public water supply dsficienciss will be considerably reducsd if the Metropolitan Water Board continue to import sufficient water from the Thames to meet their entirs dsficiency in Essex and to fulfil their bulk supply agrsemsnt with the Soutb Essex Waterworks Company. However, as is shown in 7.6, the Thames area with the Metropolitan Water Board area will itself be in deficit by 1971 and tbs availability of water for export to Essex in a drought year will depend upon sither s sufficisntly rapid developmsnt of a new source in tbs Thames or some arrangemsnt equivalent to ths present statutory provisions for reducing the statutory minimum flow over Teddington Weir (170 m.g.d.). Even allowing for thsse imports to be made in full, there will atill be a total deficiency of about 20 m.g.d. remaining in 1971.

As regards internal resources, the two small schemes (1 and 2) have a combined yield of about 3.6 m.g.d. and they therefore make little impact on the overall deficiencies. However, we consider that they should proceed if their promoters regard them as viable and justified in helping the short-term position.

Proposals have been made for four pumped storage reservoir schemes (3-6) yielding a total of 30 m.g.d. The proposals are:

(i) Maldon Reservoir (5) which is the largest of the four schemes and uses land least effectively but is probably on the poorest land. The scheme envisages storing 9,200 million gallons. The new reservoir would be used in conjunction with Hanningfield Reservoir, giving a combined capacity of 15,200 million gallons. Additional pumps would be installed at the existing Langford intake on the Rivers Chelmer/Blackwater to increase the maximum abstraction rate from 43 to 243 m.g.d. thus taking advantage of flood flows. The water would be pumped about three miles to the Maldon site through a tunnel which would also be used for conveying the stored water back to the river for abstraction at the existing intake for delivery to Hanningfield. The scheme is expensive because it seeks to exploit the run-off of the Rivers Chelmer/Blackwater to the practicable limit following the considerable storage conservation already obtained at Hanningfield. The estimated unit cost of the water yielded is over 4/- per thousand gallons treated and delivered to the service reservoir - considerably above the unit cost of water prevailing in the area and above that of any scheme (other than barrages) listed for the region.

(ii) Ardleigh and Earls Colne (3 and 4) which would utilise the run-off from the River Colne, hitherto virtually undeveloped for public water supply.

The first stage of the scheme entails the construction of a reservoir with a capacity of 500 million gallons about four miles north east of Colchester on Salery Brook at Ardleigh. It would be filled by pumping from the River Colne just above the tidal limit at Colchester and has been estimated to yield 5.0 m.g.d. A licence application has been submitted to the Essex River Authority for the Ardleigh scheme (3).

The second stage of the scheme, estimated to give a further 5.0 m.g.d. comprises a 3,200 million gallons' capacity reservoir on the Bourne Brook tributary of the Colne near Earls Colne and Halstead (4). The reservoir would be filled partly by direct run-off and partly by pumping from the River Colne. The reservoir would be used to regulate the River Colne with abstraction as for the first stage into Ardleigh.

(iii) The Roding-Wid reservoir (6) which would be situated on the River Wid east of Ingatestone and would utilise water from the River Roding; this is the other main Essex river, apart from the Colne, which has not yet been developed for water supply. The reservoir has a proposed storage capacity of 2,770 million gallons and a secondary reservoir of 680 million gallons' capacity would collect and detain direct run-off from the Wid catchment before admission to the main reservoir.

During times of high flow water would be pumped a distance of 6½ miles from the River Roding to the reservoir and the water would

he rsleased to regulate ths Rivers Roding and Wid at times of low flow. Ahstraction would he by means of a new intake at Chigwell and the water conveyed to an exteneion of the existing treatment works at Chigwell Row. The yield of the scheme ie estimatsd to he ahout 7 m.g.d. at a unit coet of under 2/6d. per thousand gallons treated ready for distrihution.

The deficiencies listed ahove for 1981 and 2001 must he met hy new conservation works in areas which can export water to Esaex, after allowing for any local schemee which might he authorised meanwhile. The rsadiest means of ohtsining snd importing further water hy the early 1970's appears to he by feeding the Rivsrs Stour and Blackwater and possihly the Colne from the Great Ouss area (Great Ouse echeme 15) thus increasing the reliahle yields of Abherton and Hanningfield hy ahout 22 m.g.d. We consider that this propoeal could he put into effect hy ahout 1971, provided that an early decision ie made to proceed, and all the indigent undertakings in Essex could he supplied hy suitahle connections from these two reservoirs. The river authorities concerned might well he giving coneideration at an early stage to the machinery wherehy this echeme could he put into effect.

The allocation of further imports into Essex and the need for the Essex storage echemes - eome of which may wsll he justifiahle as local developments - are coneidered further in the context of the regional water halance in Chapter 8. Those considerations inclnde the uee of ground water and/or surface atorage echemes in the Great Ouse and Thames catchments for providing water to Esaex, either into the rivers to increase dry weather flowe for suhsequent ahstraction or direct into the supply systems as most appropriate.

The propoeals for meeting requiremente during, say, the next dscade are unlikely to do much to improve dry weather flows in the Essex rivers as a whole, and the Essex River Authority may find it necessary to supplement these achemee with aome local storage in the headwaters to augment dry weather flows.

7.5 **Lee:**

Comhined Effective Deficiencies

Year	Puhlic Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	-	3	1	5
1981	20	15	2	35
2001	85	24	3	110

The etatutory water undertakings should he ahle to meet their eetimated demands in this area in full in 1971 hy existing arrangements to import water from the Great Ouee (see 7.2) and Thames (see 7.6) areas and hy the development of local ground-water schemes (Lee 1 and Great Ouse 4, 5 and 6).

The small industrial and agricultural deficiencies in 1971, and the suhsequent total deficienciee, will havs to he made good from ths Thames and Great Ouse areas as there is no prospect of a water hslance hased on the internal reeources of the Lee ares. The matter is discussed further in the context of the regional water halance (Chapter 8).

The area has no obvious potential resources but a possible pumped storage reservoir site exists at Cobbine Brook (Appendix IV Lee scheme 2), e tributary of the River Lee. The brook risee a little to the north of Epping and flows generally in a south westerly direction to join the River Lee just below Waltham Abbey. From the geological map it appeare thet the whole of the valley of the hrook is on London Clay. The scheme envieages a dam across the velley to flood it to a level of about 225 feet A.O.D. The volume of storage created would be approximetely 18,000 million gallons which would bave to be filled largely witb imported water probahly from the River Tbames. Assuming that the scheme immediately followed completion of the Metropolitan Water Board's reeervoirs at Wraysbury and Datcbet, Cobhins Brook reservoir would yield 58 m.g.d. based on e repetition of 1943/44 flows in the River Thames and Lee. The effect of regulating tbe flow of tbe Thames by the abetraction of ground-water (Thames echeme 17) on the yield of Cobbine Brook reservoir is mentioned in Chapter 8.

The ground-water resources of the Lee area are overdeveloped and the Hydrological Survey of the River Lee Baein (1.2) indicated tbat abstraction from the chalk aquifer exceeded repleniebment by about 10 m.g.d. The Metropolitan Water Board conducted a series of artifical recharge experiments hetween 1953 and 1958 at tbree of their well stations in the Lower Lee Valley. Fully treated water was discharged into existing wells during the winter months enebling tbeee same wells to be pumped at higher rates during tbe summer months than were possible prior to artifical recbarge. The Board have continued to practise artifical recbarge at tbese well etations since 1958 hut tbe quentity of water available for recbarge bas been limited by a shortage of spare filtration capacity due to rising conеumption. One apparent result of tbe artifical recbarge operations has heen a decrease in the rate of fall of the water table. It ie to be hoped that the exieting operations in tbe lower Lee valley will be continued and, if possible, expended as they could represent a significant conservation measure.

7.6 **Thames:**

Combined Effective Deficiencies

Year	Public Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	10	5	6	20
1981	55	25	8	90
2001	185	58	8	250

We have assumed tbat the agricultural deficiencies will be met in tbe main by private storage works and boreholes (see 5.4(ii)(a) and 5.5).

Ae regards the deficiencies of the statutory water undertakings, it should be noted that tbe quantities listed relate to 'upstream' usere, i.e. tbose undertakings whose conеumption ie returned ee effluent above Teddington Weir (eee 3.3). Provision of these quantities of water would meet the deficiencies of the 'downstream' users, i.e. tboee undertakings whose consumption witbin the area ie returned as effluent below Teddington Weir and also make tbe following amounts available in the yeers etated for re-use outside the Thames area:-

1971 : 5 m.g.d.; 1981 : 35 m.g.d.; 2001 : 135 m.g.d.

Schemee 1 to 15 lieted in Appendix IV, with a totel yield of about 50 m.g.d., would not significantly affect dry weather flows at Teddington.

Export of water to other river authority areas which would diminish these flows is undesirahle. In certain instances, provision may have to be made for the maintenance of dry weather flows locally; in others (e.g. scheme 12) increased ground-water abstraction could lead to local over-development of the aquifer. These latter schemes will require detailed investigation.

Apart from these difficulties, the further unrestricted development of supplies obtained by continuous ahstraction from boreholes would impinge on the scheme for regulation of the Thsmes flow by controlled ground-water ahstraction (scheme 17), whereas direct use of river water will usually be a natural corollary from that scheme. Consideration will have to be given to the extent to which further continuous horehole ahstraction should be allowed to occur and it may be that some undertakings which have hitherto relied solely on ground-water resources will, in the future, have to rely wholly or partly on surface abstraction to meet increased demands. However, where additional horeholes are the only reasonahly economic means of supplying particular localities, they may have to be accepted even at the expense of some effect on the regulation scheme. We hsve assumed that during the next five years such local schemes may he used to meet the deficiencies of some 'upstream' users; after 1971, however, we have assumed that the total new yield of ground-water sources - whether it includes further local development or not - will be represented hy the yield figures we have assigned to scheme 17.

The following three proposals for regional schemes are listed in Appendix IV:

(i) Scheme 16 for direct-supply pumped storage reservoirs located on the Kimmeridge clay in central Buckinghamshire with an intake about twenty miles away on the River Thames near Medmenham. There are two possihle reservoir sites, either or both of which could be developed; one site, known as Waddesdon, lies about 7 miles west of Aylesbury whilst the other, the Whitchurch site, lies about the same distance to the north of that town. Both sites appear to have good storage potential and site investigations are in hand. On the assumption that 25,000 million gallons of storage could be provided, and given adequate conditions of ahstraction from the river, the yield could be about 70 m.g.d. on the basis of a repetition of 1943/44 river flows.

The scheme would give users in Buckinghamshire the advantage of prolonged storage and would avoid abstraction of dry weather flows for such users. This advantage, which is common to all direct-supply reservoirs, must be weighed against the advantages to the river of regulation by storage in the upper reaches. Moreover, in this instance, we feel that the scheme for regulating the River Thames by the use of ground-water storage may well provide a supply in Buckinghamshire at appreciahly lower cost and may therefore he chosen for prior development. We deal with this matter more fully in Chapters 8, 9 and 10.

(ii) Scheme 17 is the Thames Conservancy's project for regulation of the river by controlled ground-water abstraction. Basically this would involve pumping from horeholes into the tributary streams in dry weather with the consequence that there would be less ground-wster leakage to these streams when surface run-off is more plentiful. An important advantage of this scheme is that it could be developed in stages and practicable rates of development might be 30 m.g.d. by 1971, 125 m.g.d. by 1981 and 200 m.g.d. by 1991.

(iii) Scheme 18 is for regulation of the Thames by means of pumped storage reservoirs at Bampton, Enhorne and Otmoor, three sites which were

considered some years ago hy the Metropolitan Water Board for their own storage purposes. The approximate storage capacities and yields of these proposed rsservoirs are, respectively: Bampton 45,000 million gallons - 70 m.g.d., Enhorns 55,000 million gallons - 85 m.g.d., Otmoor 32,000 million gallons - 55 m.g.d. Failing schems 17 it might he possihle to produce a suhstantial proportion of the ultimats yisld of that schsms hy a comhination of rsgulating reservoirs.

The three schsmes (16, 17 and 18) are all suhject to investigation in the field and their estimated yields may he radically revised in due course. They are not mutually exclusive hut we have not had time to consider their interaction or the sequential effects of such a ssriss of regulating reservoirs.

Schems 17 for regulation of ths rivsr hy ground-water ahstraction deserves priority hscsuse the estimated unit cost of water is lower than for the surfacs schemes and there would be leas interfsrencs with the sxisting uss of land. In examining the future resourcss halance of ths area we have assumed that ths schems will he developed to the yields given ahove, with dirsct ahstraction from the regulated river to statutory wster undertakings in the Colne Valley area (scheme 17a), the Bucks Water Board and othsr users. The surface storage schemes have heen considered as supplementary or alternative developments if the ground-water scheme fails to meet requirements. In Chapter 8 sstimates are given of the possihls yields of schemss 16 and 18 if thsy followed the full development of schsme 17.

We envisage the situation at future dates as follows:-

1971: The sum of the deficiencies of public water supply and industrial users 'upstream' of Teddington Weir is 15 m.g.d. If this is made good, 10 m.g.d. (puhlic water supply) would he returned to the river for reuse and would suffice to cover ths internal deficiencies of the 'downstream' ussrs. Howevsr, regard must he had to the Metropolitan Water Board's existing arrangements for the transfer of Thames water to thsir consumers in the Lee and Essex areas. By 1971 theas transfers are expected to exceed the Board's surplus in the Thames area hy 3 m.g.d. In addition to thsse internal demands, the Board have an agreement to afford the South Essex Watsrworks Company a hulk supply of water and the Company might requirs 20 m.g.d. in 1971. Thus, the extra water wbich would he requirsd in ths Thames to meet all these ohligations, should 1971 he a drought year, would hs the sum of these transfers, plus the effective deficiency of the 'downstream' users (see Appsndix I Thames Tahle III.A) plus the industrial deficiency, i.e. 3 + 20 + 5 + 5 = 33 m.g.d.

A yield of, say, 30 m.g.d. may he availahls from the initial stages of the Thames ground-water scheme if, following successful tests, the scheme is authorised for dsvelopment. Failing this, extra water could he obtained (as at present) hy the operation of an arrangement for a reduction, during drought, of the statutory minimum flow of 170 m.g.d. ovsr Teddington Weir, such an arrangement providing also for direct ahstraction hy the Colne Valley, Lee Valley and Rickmansworth and Uxhridge Vallsy Water Companies. Nevertheless it is desirahls to minimise the risk of rsducing the flow over Teddington Weir helow 170 m.g.d. and ths following expsdients dsserve consideration:-

(a) Pumping into streams from horsholes water surplus to the immediats requirements of undertakings in the Thames Basin. There will he some surplus authorised resourcss and there exist other boreholes for which full powers of ahstraction have not yet hsen authorised. Ths net increment to river flow from these resources can be assessed

ae a suitable fraction of tbe pumping rate and it would be wortb looking into this to see if a significant quantity would be available and to aee how the administrative problems could be overcome.

(b) Completion of etage II of Oxford Corporation's Farmoor scheme would make availsble for river regulation about 1,700 million gallons of storage surplus to Oxford's immediate needs and would maka about 10 m.g.d. available for abatraction from the lower reaches of tbe Tbames. The arrangement would be subject to tbe settlement of satisfactory financial terms under whicb Oxford Corporation would construct tbe stage II reservoir earlier tban required for their own purposes, the reservoir preaumably reverting to their use in due course.

1981: At tbis date, the deficiencies, 90 m.g.d. are leea than the yield, 125 m.g.d., suggested for scbeme 17. If this quantity should be available (poseibly together witb any surplus capacity from the Farmoor scbeme) it would provide for all tbe abstractions in the Thames ares and make about 80 m.g.d. (including 35 m.g.d. returned by tbe 'upstream' users) available for tranefer to areas further east.

If scbeme 17 doee not proceed as envisaged, scbeme 16 (resarvoirs in Buckingbamsbire) could probably be developed by 1981, meeting the raquirements of tbe Bucke Water Board (and perbaps some adjecent sreae) by direct supply. Uea of tbe remaining capacity of tbose reservoirs to regulate the Thames, coupled with use of tbe remaining spare capacity at Farmoor and some further continuous borebole eupplies would probably suffice to cover tbe balance of deficiencies in the Thames area. Scbeme 16 would bave to be compared with other proposals for pumpad storage sites in tbe Thsmes area (scbeme 18); but eubject to feasibility one or more of these would serve to meet 1981 requirements as an alternative to scheme 17.

Successful operation of regulating schemes, whetber from ground or surface storage, to meet tbe needs of abstractors from tha Thames will necessitate some review of existing powere of abstraction, the most important of wbich are those of tbe Metropolitan Water Board.

2001: The difference between tbe estimated deficiancy of 250 m.g.d. snd tbe eetimated yield, at full development, of scbeme 17 (200 m.g.d.) would be met by a greater measure of successive re-use by the 'upstream' undertakings. After providing for tbe needs of 'downstreem' ueers, tbe surplus available for export at Teddington would be about 90 m.g.d. if the new resources provided for 'upstream' users were limited to 200 m.g.d.

Failing scheme 17, it appears tbat a similar yield might be made available from tbe surface storage scbemes (16 and 18) if ell of tbose mentioned were to prove feasible. We must empbasise, bowever, tbst tbe ultimate combined yield of these surface storage schemes csn be little more tban a speculation pending eita investigation and hydrological enalysis.

To sum up, tbe Thames araa can meet its estimated deficiencies until tbe year 2001 if the plans of the Thames Conservsncy for river regulation witb ground water can ba raalised. Failing tbis, it seems probable that a combination of several pumped storage reservoirs could meet these daficiencies. In eddition to meeting tbe ares's internal deficiencies, the Thames area sbould also be able to meet tbe needs of that part of tbe Metropolitan Water Board'e undertaking outside the Thames area and that Board's commitment to supply 20 m.g.d. to the South Essex Wsterworks Company

in 1971 (if necessary by the operation of powers to reduce the flow over Teddington Weir in a drought year). Subsequently, tbe estimated yields from the Thamea controlled ground-water abstraction scheme will cover deficiencies in the Thames area and will make about 80 m.g.d. availshle for export to otber areas in 1981 and about 90 m.g.d. in 2001. The 80 m.g.d. available in 1981, together with the surplus of the Metropolitan Wster Board's authorised resources, would meet the deficiencies of the Metropolitan Water Board in the Lee and Essex areas together with 20 m.g.d. export to South Essex Waterworks Company and permit a further export of ahout 35 m.g.d. In 2001, however, little surplus would remain after meeting the area's internal deficiencies, those of the Metropolitan Water Board in the Lee and Essex areas and their export of 20 m.g.d. to South Essex Waterworks Company.

7.7 **Kent:**

Combined Effective Deficiencies

Year	Public Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	4	4	8	15
1981	22	10	12	45
2001	83	20	16	120

The local ground-water schemes (1 to 22) are estimated to yield 27.5 m.g.d. including 2.5 m.g.d. (schemes 1 and 2) which may not be available from the aites specified hecause the dispoaal of mine-drainage into the chalk aquifer has locally increased chloride content of the ground water, snd 6 m.g.d. (schemes 10 and 11) which are dependent on additional intermittent abstractions to maintain the flow in the River Stour. Subject to these reeervations we believe that 27.5 m.g.d. will be available from the ground water.

Theoretical calculations on percolation, when applied to the chalk aquifer in north west Kent, indicate that the aquifer is already over-pumped, a condition first suggested in the Kent Rivers Hydrological Survey. (See 1.2). If detailed observations of gronnd-wster levels confirm this to be so, measures will have to be taken either to recharge the aquifer artificially or to supply some ahstractors by other means. Other undeairable featurea of locsl over-development which will have to be checked are tbe saline intrusion into the aquifer from the Thames estuary and the loss of water by natural recharge from the Rivers Darent and Cray to the extent that their flows are at times inadequate. One suggestion for augmenting the flows in the River Darent is to make use of atorage in sand and gravel pits in the Sevenoaks area.

Schemes 23 to 27 relate to pumped storage reservoirs which in total would yield approximately 60 m.g.d. The River Medway scbeme (24 - Bewl Bridge reservoir) has heen fully investigated and an application for powere to develop is being prepared. If approved, the echeme wonld he developed in atages to give an immediate yield of 10 m.g.d. increasing to 14 m.g.d. by the late 1970s. The final stages would then need to he reviewed as they pre-suppose a reduction of the river flow at Teston from 90 m.g.d. to 50 m.g.d. If this reduction were possible the yield of the scheme would be raised to about 25 m.g.d. Preliminary investigation suggests that further reaervoirs could be conatructed at Lamberhurst, Winbridge or Dundle (scheme 25) with a combined yield of about 15 m.g.d. making a total of 40 m.g.d. from the River Medway and its tributaries.

The other pumped storage schemes on the Rivers Stour (23) and Rother (26 and 27) should be investigated in more detail.

If all the schemes listed in Appendix IV are developed the estimated demands of the area would be met until about 1990. It is anticipated that further schemes could be designed to make the area self-sufficient up to the end of the century.

7.8 **Sussex:**

Combined Effective Deficiencies

Year	Public Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	2	-	3	5
1981	11	1	3	15
2001	36	2	3	40

The schemes listed for Sussex (excluding the Chichester barrage scheme) together produce a yield about equal to the estimated total deficiency in 2001 but we have little doubt that these schemes do not exhaust the potential resources of the area, particularly in the Arun and Adur valleys.

The local schemes - apart from the Pulborough boreholes - meet the needs of the statutory water undertakers in the eastern part of the area until the 1990's, but after that, on present estimates of demand, Hastings and Eastbourne will have to look to further sources.

Development of the Sussex Ouse resources by regulating and/or direct supply (pumped storage) reservoirs (scheme 7) seems the obvious course to meet the demands in the central and northern part of the area. There are also possibilities of some water being available from this area for export to meet local deficiencies in the southern part of the Thames area. Several potential sites for regulating reservoirs, totalling some 3,000-4,000 million gallons capacity, exist on the upper tributaries of the River Ouse near Uckfield, Ardingly and Haywards Heath but these will require careful examination of the geology and extensive site investigation before selection. Sociological and amenity factors will also be particularly important.

The western part of the Sussex area which includes the Arun and Adur valleys and the western part of the South Downs probably offers the greatest scope for water supply development. This area could be developed by groundwater schemes in the chalk area (scheme 8), to meet the demands of development on the coastal strip eastwards and westwards and obviating the undesirable possibility of seasonal change from chalk-derived to river-derived supplies, and by pumped storage/regulating schemes for the Wealden catchment, and on the tertiary formations overlying the chalk, such development would be the obvious course to follow if the Chichester barrage did not prove to be an attractive proposition.

The Chichester Herbour barrage proposal (scheme 9) involves impounding the direct run-off from the chalk and tertiary catchment to Chichester Harbour plus quantities to be pumped from the middle reaches of the River Arun to the east and offers a fuller development of these resources with a potential yield of 35-40 m.g.d. The scheme envisages the impounding of 12,000-14,000 million gallons of usable water by two comparatively small berrages and may offer the prospect of relatively cheap water at full yield.

The harrage would straddle the river authority houndary with Hampshire and it could afford a supply to tha eastern part of that area which is affected hy the Portsmouth/Southampton new town proposals; Portsmouth Water Company already imports supplies to the Hampshire part of their etatutory area from west Sussex. Such a supply to eouth east Hampshire could utilise the full potential of the scheme as at present foreseen, hut larger-scale possibilities present themselves such as the storage of surplus run-off from the Hampshire rivers and the export of water to the Thames area via the Arun-Wey gap.

The Committee therefore consider that this barrage proposal deserves further investigation into prohabla yield and coat by the two river authorities concerned to ascertain whether it merits a feasibility etudy. There is at preeent insufficient information to say whether this source would ba worth developing to help to supply the regional 'deficiency zone' or whether a scheme of thie kind would, on balance, enhanca or impair the notabla amenities of Chichestar Harhour.

7.9 **Hampshire:**

Combined Effective Deficiencies

Year	Public Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	11	-	-	10
1981	43	1	-	45
2001	116	2	-	120

A substantial part of the deficiencies for Hampshire in 1981 and 2001 may be ascribed to the propoeed development - still in an early planning stage - of a new conurbation in the Southampton/Portsmouth area. The deficiencies might he substantially increased when a decision as to the full ecale of this development has been reached.

The resources of Hampshire have been comparatively little exploitad for water supply. Moreover, run-off to rivers is more constant than in most other areas because of the preponderant contribution made by baseflow from the chalk. The eesential problem in the Hampshire area ie, therefore, that of reconciling the interests of abstractore with those of other water users, a.g. fishermen, and taking measures, where possible, to improve further upon the natural regulation of the rivers.

The proposed borehole schemee 1 to 6 and the group of horeholes, schame 10, - yielding in all about 40 m.g.d. - are well within the available capacity of the area as a whole, although we have insufficient information to evaluate individual schemes or their comparative effects on dry weather flows.

The suggested continuous direct river abstraction schemes, 8 and 9, together with any required abstractions for spray irrigation, may well be acceptahle to the river authority without accompanying conservation works. Together with the borehole schames thay would apparently euffice to cover deficiencies until the late 1980's.

Beyond that date, schemes 7 and 11 for surface storage, if proved feasible, could meet the remaining deficiency in 2001. The authorisation of further direct ahstractions from the rivers, supported when necessary, by a controlled ground-water ahstraction schame from the chalk similar to that under considaration in the Thamee area, may well, however, prove more attractive from the cost and land use aspects. By tha time a decision needs

to be taken on whether future requirements should be met by the provision of surface reservoirs much more should be known about the feasibility and potentiality of the Thames ground-water regulation scheme and pilot works could have been carried out in Hampshire. It will, therefore, then be possible to decide which of the two methods should be used to meet Hampshire's future deficiencies. Meanwhile, abstraction works on the rivers and many of the borehole works needed to meet interim deficiencies could be designed with a view to incorporating them into a ground-water regulation scheme.

If the Hampshire area contrives to meet all its needs in these ways by 2001 it will still have developed for water supply less than 30 per cent of its average annual run-off - compared with well over 50 per cent development which we envisage for the Thames area - and it may be able to offer some assistance to the Thames and its dependent areas if full regulation of the ground-water baseflow should prove practicable.

Virtually no direct industrial demand has been allowed for in calculating the future requirements of this area. The planned development of a new conurbation in the coastal area, which accounts for almost all the growth in public water supply demand, should, however, lend itself to the development of sewage effluent recovery for industrial use if a substantial demand for second-grade water were to develop.

7.10 **Avon and Dorset:**

Combined Effective Deficiencies

Year	Public Water Supply m.g.d.	Industry m.g.d.	Irrigation m.g.d.	Total (to nearest 5 m.g.d.)
1971	-	-	-	-
1981	7	1	-	10
2001	36	2	-	40

Our remarks about the modest scale of demands in relation to available resources in the Hampshire area apply with even greater force to the Avon and Dorset area where, even if all deficiencies estimated for 2001 are met from the area's resources, only about 12 per cent of the mean run-off will have been utilised.

If, as we assumed in Chapter 5, both high value and low value crops make an effective irrigation demand, the daily irrigation use might reach a peak of 30 million gallons, but some of this would be ground-water use and the impact on dry weather stream flows is likely to be acceptable to the river authority.

The schemes listed in Appendix IV - mostly local borehole developments - are estimated to yield in total about 25 m.g.d. Whilst we have insufficient information to evaluate the individual proposals we have no doubt that very much greater supplies can be obtained by continuous borehole abstraction, by direct river abstraction and/or by ground-water regulation of rivers.

So far as the region as a whole is concerned, therefore, the main interest is in the export possibilities of this area. Two approaches to the conservation of ground water for export into the Thames area and thence to the areas of severe deficiency seem possible.

The ground water could perhaps be developed in the way proposed for the Ely Ouse in the Report on The Water Resources of the Great Ouse Basin: i.e. boreholes would be put down for supply, feeding into pipelines (or possibly a canal) crossing the watershed into the Thames area with further 'compensation' boreholes being put down for feeding watercourses in dry weather.

This arrangemsnt would withdraw the effective yield from flows in the Avon and Dorset rivers and development would he limited by the minimum acceptahle flow requirements in those rivers. In the Ely Ouse catchment a yield of ahout 80 m.g.d. (125 m.g.d. with recharge) was anticipated from an average percolation income of 225 m.g.d. which is very similar to ths mean percolstion income of that portion of the Avon and Dorset chalk lying within the catchment of the Avon.

Because of the nature of the chalk of Salishury Plain and the adjoining areas, however, there is likely to be more difficulty than in East Anglia in tapping it by widely distrihuted horeholes, and the form of exploitation proposed for the Thames Basin - i.s. feeding the rivers from horeholes sited in the valleys - is likely to he more appropriate. If water is then ahstracted from the lower reaches of the rivers and returned to the hesd of the catchment hy pipeline, dry weather flow will he improved throughout much of the system and yields may he increased hy regulating direct run-off.

These possihilities will deservs further consideration in the light of experience in the Thames and, possibly, the Great Ouse areas. If the Thames project is successful there will he a possihility of a further 100 m.g.d. or more (although necessarily at considerahly greater cost) hy its extension into the Avon and Dorset, and perhaps Hampshire, areas.

CHAPTER 8. RESOURCES BALANCE OF CENTRAL AREA

8.1 Scope of Chapter

Reference was made in 6.6 to tbe 'deficiency zone', which is sbown coloured pink in Map 7. The boundary we have cbosen is somewhat arbitrary but is intended to define a zone characterised by fsirly concentrated demands which will have to be met at least in part by substantial imports, primarily from adjoining parts of the Welland and Nene, Thsmes and Great Ouse areas. This chapter is concerned with tbe resources balance of the deficiency zone and tbese adjoining areas. This combined area, which we refer to subsequently as the 'central area', is shown within a black stippled edging in Msp 7. We would point out tbat we have defined s deficiency zone simply as a convenient concept for the analysis of needs and the comparison of sources: for instance, it should not be regarded as having exact plsnning implications.

The requirements of the deficiency zone, whicb includes many of the important growth areas in south east England, virtually define the regional water problem, and it is essential to consider these requirements in relation to possible surpluses elsewhere and to compare tbe costs of imports from various sources into the several sections of the zone indicated in Msp 7. The scope for a very large new regional source - sucb as a freshwater reservoir in the Wasb - would also be determined by the estimated requirements of tbis zone.

We would empbasise thst for the purpose of this chspter - as for the relevant parts of Chapter 7 - we have selected notionsl delivery points for bulk supplies and assigned certain supplies to particulsr statutory water undertakings and areas merely to simplify tbe analysis of tbe region as a wbole and to point tbe way to correct decisions about tbe development of regional resources. It is not our intention to imply that sources should be allocated to those particular undertakings or tbat bulk distribution should be engineered along particular lines unless more detailed surveys support such conclusions.

Table G sbows the overall deficiencies which sre likely to obtain in the Sections of the deficiency zone defined in Map 7: i.e. the supplies whicb will be required over and above those which will be available from resources now authorised. The tabulated figures include the relevsnt industrial deficiencies in each Section and the agricultural deficiencies in tbe Upper Lee, South Essex and Nortb Essex Sections; for convenience all the industrial deficiencies in the Thames Conservsncy area have been included in the Bucks, Colne (Tbames) and London Sections.

TABLE G

ESTIMATED ADDITIONAL QUANTITIES OF WATER REQUIRED IN THE VARIOUS SECTIONS OF THE DEFICIENCY ZONE

Section	Statutory water undertakings included in Section	Deficiencies (to nearest 5 m.g.d.)			Assumed elevation (feet above O.D.) at central delivery point in Section (for costing purposes)
		1971	1981	2001	
NORTHAMPTON	Higham Ferrers & Rushden W.B. Mid Northamptonshire W.B.	–	20	60	450
BUCKS	Bucks W.B.				
	(Thames area)	–	10	30	450
	(Great Ouse area)	5	20	50	450
COLNE (THAMES)	Colne Valley W. Co. Lee Valley W. Co. (in Thames area) Rickmansworth & Uxbridge Valley W. Co.	15	40	75	450
LONDON	Croydon C.B.C. Metropolitan W.B. South-West Suburban W. Co. Sutton District W. Co. Woking & District W. Co.	10	45	140	250
UPPER LEE	Lee Valley W. Co. (Lee & Essex areas) Luton W. Co. (Lee & Thames areas)	10	35	70	400
SOUTH ESSEX	Chelmsford B.C. Chelmsford R.D.C. Maldon B.C. Maldon R.D.C. Southend Waterworks Co. South Essex Waterworks Co. Witham U.D.C.	30	55	110	250
NORTH ESSEX	Braintree & Bocking U.D.C. Braintree R.D.C. Colchester & District W.B. Halstead U.D.C. Halstead R.D.C. Ipswich C.B.C. Samford R.D.C. Tendring Hundred W. Co. West Suffolk W.B.	10	25	65	250
TOTALS		80	250	600	

In comparing the estimated additional quantities of water required to be brought into supply in the deficiency zone with overall resources it should be borne in mind that a part of the amounts to be distributed in the Bucks and Colne (Thames) Sections will return to the Thames above Teddington Weir to augment the resources available to the London Section. By deducting these amounts (Table H line 2) from the deficiency zone's total requirements (line 1) the net requirements of that zone become apparent (line 3). By adding the deficiencies of those parts of the Great Ouse and Welland and Nene areas outside the deficiency zone (line 4) to the net requirements of the deficiency zone we obtain the overall net deficiencies of the central area (line 5). Deficiencies in the Upper Thames area do not affect these net deficiencies since we have assumed that all the water used there will be re-used in the deficiency zone.

TABLE H

NET RESOURCES REQUIRED IN CENTRAL AREA

to nearest 5 m.g.d.

		1971	1981	2001
1	Required additions to supply in deficiency zone (area shown coloured pink in Map 7) (totals of Table G)	80	250	600
2	Deduct re-use of water ex Bucks and Colne (Thames) Sections	- 10	- 20	- 50
3	Net new requirement in deficiency zone	70	230	550
4	Add other deficiencies in Great Ouse and Welland and Nene areas (area shown with black stippled edging and north of area shown coloured pink in Map 7)	+ 15	+ 40	+100
5	Net central area deficiencies	85	270	650

These net central area deficiencies must be met by major new resources and they are compared with the available resources in 8.3 below. It is also of interest to assess the total amounts to be added to present supplies in the central area, for comparison (8.4 below) with the estimated cost of the works to be carried out. To calculate these amounts we must add to the required major resources (Table H, line 5) the amounts which will be obtained by re-use of water in the Thames and Great Ouse areas, the yield of authorised works which have not yet been completed and the net yield of certain local sources which remain to be developed in the central area. These additions bring the total expected increases in supplies within the central area to about:-

250 m.g.d. in 1971
500 m.g.d. in 1981
1,000 m.g.d. in 2001

These figures exclude the re-use of water by industry which does not require either new source works or public delivery works and they also exclude irrigation supplies, apart from the required imports to the Lee and Essex areas.

8.2 Costs of Imports

We have tried to determine the comparative unit costa of water deliverad from various alternative aources into tha seversl Sections of the deficiency zone listed in Tsble G. We must emphasise that in the absence of dependable yield etudies for many of the schemes referred to at (a) to (k) below and in advance of field investigation and preliminary design for nearly all of them these estimated unit costs can only be tentative. However, tbey suffice to indicate that most of these schemes could provide water for aupply in the deficiency zone at costs which would bear compariaon with those of major increments of supply recently provided or authoriaed in the zone and probably well below those which would obtain if supplies were sought from radically new sources - major barraga schemes, desalination plants, importa by canal or aqueduct from the north or west of England. They also help to indicate, so far as coet is s criterion, which sources can beat serve each Section and the preferabla order of development.

All the unit costs given in Table J are in pence per thousand gallons of traated water delivered to service reservoirs at a representative delivery point in each Section of tbe deficiency zone and at the elevations liated in Table G. The costa include capital chargea and running costs but excluda the effects of local authority rates. They would apply if each scheme were developed separately to its full capacity or to meet the maximum requirement listed in Table G for the Sections to ba supplied from the scheme (whichever ia the less); they would not neceesarily spply if a scheme were superimpoaed on other listed schemes which had been developed previously.

The supplies considered are as follows:-

(a) Surplus Great Ouse run-off delivered by pipeline and river to share existing storage in Essex (i.e. Abberton and Hanningfield Reservoirs) and delivered by tunnel from Brownshill Staunch to Diddington Reservoir.

(b) Watĕr from ground-water storage in the Tbames Basin (cost in River Thames assumed to be 3d per thousand gallone as assessed by the Thsmes Conservancy).

(c) Water from ground-water storage (low level) in the Great Ouse Baain.

(d) Nene/Welland water from pumped storage reservoirs.

(e) Great Ouse water from an appropriate pumped atorage reservoir.

(f) Thames water from pumped storsge reservoirs in Buckinghamshire.

(g) Thames/Lee water from pumped storage raservoir at Cobbins Brook.

(h) Thames water sustained by pumped storage regulating reservoirs in the Thamea Basin

(j) Water from ground-water storage in Avon & Dorset and/or Hampshire areas delivered via the Thames.

(k) River Severn water at an assumed conservation charge of 3d per thousand gallons in the Severn pumped via a tunnel into the headwaters of the River Thsmes to augment flowa when required.

TABLE J

APPROXIMATE COMPARATIVE UNIT COSTS OF TREATED WATER
(PENCE PER THOUSAND GALLONS)

Schema	Source catchment	Type of storage	Delivered to notional distribution point in Section:-						
			Northampton	Bucks	Colne (Thames)	London	Upper Lee	South Essex	North Essex
			(See Map 7)						
(a)	Great Ouse	existing pumped storage reservoirs	32(i)	35(i)			32(i)	33(ii)	28(iii)
(b)	Thames	ground water		26	24	22	28	29	36
(c)	Great Ouse	ground water					36	34	34
(d)	Nene/Welland	pumped storage direct supply reservoirs	27						
(e)	Great Ouse	pumped storage direct supply reservoirs	32(iv)	35(v)			35(iv) or 35(vi)	36(vi)	31(vi)
(f)	Thames	pumped storage direct supply reservoirs		34(vii)					
(g)	Thames/Lee	pumped storage direct supply reservoirs				34(viii)	35(viii)	34(viii)	
(h)	Thames	pumped storage regulating reservoirs		36	35	33	39	39	46
(j)	Avon/Test	ground water		37	36	34	40	40	47
(k)	Severn	impounding regulating reservoirs		37	36	34	40	40	47

(i) via Diddington Reservoir
(ii) via Renningfield Reservoir
(iii) via Abberton Reservoir
(iv) via Abbotsley Reservoir
(v) via Whitchurch Reservoir
(vi) via Great Bradley Reservoir
(vii) via Waddesdon Reservoir
(viii) via Cobbins Brook Reservoir

NOTE: These are minimum unit costs - the order of development will reduce some yields and so increase those unit costs.

8.3 **Deployment of Available Surplus:**

Of the major storage schemes under consideration to meet the deficiencies listed in Table G the proposals for exploitation of ground-water storage appear to be the most attractive on general grounds and in the light of the costs tabulated in Table J. We would point out that, unlike surface storage schemes in the area, the Great Ouse ground-water scheme 8.2 (c), would provide a sustained flow of 70 m.g.d. at Denver Sluice in addition to providing the amounts to supply listed in Appendix IV. We consider that surplus ground water from either the Thames or the Great Ouse areas could be supplied at reasonable cost in Essex and Hertfordshire, the economic line of demarcation between them running somewhere through mid-Essex.

Table K shows the resources which might be made available within the central area to meet the deficiencies listed in line 5 of Table H.

The yields given in this table for the Great Ouse ground water schemes exceed the net or 'export' yields listed in Appendix IV by the estimated requirements in the catchment of the Ely Ouse, because it is assumed that such requirements will be met en route out of the additional water provided to sustain a flow of at least 70 m.g.d. at Denver Sluice.

TABLE K

m.g.d.

		1971	1981	2001
REQUIRED RESOURCES (Table H: Line 5)		85	270	650
AVAILABLE RESOURCES:-				
Type of source	Catchment			
Transfer of authorised surplus	Great Ouse	(i) 12		
	Thames	(ii) 10		
Abstraction to existing storage	Great Ouse	(iii) 37	(iii) 37	
Ground water	Thames	(iv) 30	125	200
	Great Ouse	--	(v) 90	(vi) 155
Pumped Storage (Direct Supply)	Nene/Welland		(vii) 20	50
	Thames			(viii) 50
	Great Ouse			(ix) 60
	Thames/Lee			(x) 40
Pumped Storage (Regulating)	Thames			(xi) 60
APPROXIMATE TOTAL AVAILABLE		90	270	615

(i) Great Ouse Water Authority (Diddington Reservoir)

(ii) Oxford C.B.C. (Fermoor) etc. (Alternatively reduce statutory minimum flow over Teddington Weir)

(iii) Great Ouse schemes 13 and 15

(iv) Thames Scheme 17 (Failing this supply reduce statutory minimum flow over Teddington weir)

(v) Great Ouse scheme 18a including 10 m.g.d. supplied in Ely Ouse catchment

(vi) Great Ouse scheme 18a, plus 18b or 16, including 30 m.g.d. supplied in Ely Ouse catchment

(vii) One surface storage scheme required

(viii) Assumed yield of Thames scheme 15 when superimposed on Thames scheme 17

(ix) Great Ouse schemes 14 and 17

(x) Assumed yield of Lee scheme 2 when superimposed on Thames 17 and 16

(xi) Assumed yield of Thames scheme 18 when superimposed on Thames 17 and 16 and Lee 2

1971: It is evident that if works necessary for the full utilisation of the potential of Diddington Reservoir (including the proposed new intake at Brownshill Staunch) together with the delivery of Great Ouse water into rivers in the Essex area were to be completed in time these would suffice to meet the needs of the Bucks and North and South Essex Sections, provided that the Metropolitan Water Board were able to supply 20 m.g.d. to the South Essex Waterworks Company.

Distribution of Diddington water to consumers in the Bucks Section will require the completion of a link main from Ampthill Reservoir to (say) Bletchley Reservoir. Completion of the link from Sundon Reservoir to the Lee Valley Water Company (with supplementary boosting if necessary) would enable that Company to take 5-10 m.g.d. more Diddington water than is now authorised.

The availahle yields in the Thames area nsed to he augmented snd this could he done hy one or more of the measures mentioned in 7.6; however, it may he necessary in the event of a severe drought to make an arrangement equivalent in effect to the present statutory provisions for reducing the minimum flow of 170 m.g.d. over Teddington Weir.

The effective spplication of the increased yields avsilehle in Essex would depend on suitahle connections from Ahherton and Hanningfield Rsservoirs.

It may hs possihle to design and complete certain storsge schemes in Suffolk and Essex by 1971 in lieu of, or in addition to, the supply of Great Ouse water to those areas. It appears to us that a local scheme (auch as the Washhrook Reservoir, East Suffolk and Norfolk scheme 7,) for supplying the Ipswich area would he more economic than a supply from Abherton Reservoir. In Essex, on the other hand, the provision of Great Ouse water (winter pumping) in order to meet requirements five or aix years hence seems to he an appropriate first step towards a long-term regional pattern, reliance being placed meanwhile on assistance from the Metropolitan Water Board. This conclusion, however, is not intended to prejudice local applications to develop further storage schemes in Essex where these can bs shown to he more economic or more convenient in operation than the importation of Great Ouse water and/or relisnce on supplies from the Metropolitan Water Board. Such schemes, if sound in themsslves, would not come amiss in view of long-term requirements, and investigations into certain of these schemes are proceeding.

In the years after 1971 we hope that an increasing supply will hs ohtained from the Thames and Great Ouse ground wstsr schemes. The successful development of these schemes to give the yields listed in Tahle K cannot he taksn for granted, however, and failing these supplies alternstive sources will have to be available in the early 1970's. The only suitahle source(s) would he one or mors of the pumped storsge reservoir schemes and construction would have to commence ahout four years hefore the required date of completion.

It may, therefore, he necessary to embark on one or more of these reservoirs hy, say, 1968 if development work on the ground-water schemes is not showing promise hy that date.

1981: We have ssaumed that controlled ground-water abstraction schemes can hs developed to more than a half of the estimated ultimate yield in the Thames area end to the full yield (without recharge) in the Great Ouse area hy 1981. If developed at this rate they would make good most of the outstanding deficiency at that date and completion of one major storage scheme would cover the halancs.

In view of the deficiencies in the Northampton Section the Empingham/Manton pumped storage schsme appears to he the most suitable for development at this stage; this would also enable the Great Ouse Water Authority to continue to supply an extra 10-15 m.g.d. to the Lee Valley Water Company as well as meeting increased demands in Bedfordshire and Huntingdonshire.

It is evident that construction of the mains network illustrated in Map 7, if it included a tunnel or lifting stations along the Old West River from the Ely Ouse to Brownshill Stsunch, would complete a double circuit of conduits linking the Rivers Thames and Great Ouse and that availahle yields from conservation works on these rivers

could be disposed around this circuit in a variety of ways. It would he premature to take firm decisions now on the capacity of each link of ths circuit or the allocation of supplies to particular areas or water undertakings and any assumptions we have made will necessarily be subject to review in the light of progress with the ground-water schemes, site investigations for reservoirs, future population movsments and more exact estimates of cost.

However, it seems likely that from ths mid-1970's it will be expedient to meet the whole of the Bucks Section deficiency with water from the Thames (regulated hy the controlled ground-water ahstraction scheme) via a pipeline from the Henley/Medmenham area and to use any remaining Thames surplus (possihly 30 m.g.d. in 1981) in the South Essex Section (via the existing tunnel) and in the Lee Section (Lee Valley Water Company) via connections from the proposed Colne Valley main to Harefield and Arkley Reservoirs.

If, on the other hand, the controlled ground-water abstraction schemes were developed less rapidly than we have assumed, it might prove necessary to proceed with a furthsr storage scheme (e.g. Great Bradley or a reservoir in the Bucks Section fed from the Thames) or to expedite completion of ths Empingham/Manton schems and to terminate the supply from Diddington to the Northampton Section.

The availahle yield of the Great Ouse ground-water scheme would cover requirements in the Ely Ouse, Tidal Ouse and Wisbech areas, and the surplus, together with watsr pumped from the Ely Ouse into the Essex rivers, (in total about 80 m.g.d.) would he applied against the deficiency in the North Essex Section and any remaining deficiency in the South Essex and Upper Lee Sections.

2001: It is evident that the possihle yields listed in Tahle K do not meet the estimated regional deficiency in 2001. The suggested yield of 150 m.g.d. ohtained hy developing all the listed surface storage schemes for Thames water after ohtaining 200 m.g.d. from the Thames controlled ground-water abstraction scheme, is little more than a speculation in so far as no study has been mads of the hydrology of such a combination of schemes. However, even if a somewhat higher comhined yield were attainahle it would almost certainly prove uneconomic to impose such a succession of schemes on the River Thames.

Apart from the Wash Barrage scheme, only one of the regional sources discussed in Chapter 7 shows any promise of halancing the regional account: that is, the exploitation of ground water in areas south of ths Thames (especially Avon & Dorset) in order to supplement flows in the Thames. In terms of unit cost of water there is little to choose, on present estimates, hetween the Avon & Dorset development, the development of a certain amount of pumped storage regulation in the Thames basin and the import of water from the Severn catchment, and further study must he made of each of these proposals. We have no reason to doubt, however, that the deficiencies can be made good hy one or more of these means. If the development of regulating reservoirs on the Thames were discounted as uneconomic an import of about 95 m.g.d. from areas south of the Thames or from the River Severn would be needed to balance the account.

If opportunities for ground and surface storage of water within the region are to be exploited to economic limits, a possihle disposition of resources in the year 2001 might therefore he as shown in Table L.

TABLE L

POSSIBLE DISPOSITION OF MAJOR NEW RESOURCES IN CENTRAL AREA IN 2001

Distribution Section	Item	Gain m.g.d.		Loss m.g.d.	
		New Source	Transfer In	Transfer Out	Net use
NORTHAMPTON	1. Transfer from Empingham/Manton Reservoirs (Welland and Nene Area)		50		
	2. Transfer from Great Ouse (excluding 12 m.g.d. now authorised)		10		
	3. New requirement in Northampton Section				60
BUCKS	1. Waddesdon Reservoir (Thames)	50			
	2. Whitchurch Reservoir (Great Ouse)	30			
	3. Transfer from remainder of Thames area		20		
	4. Net new requirement in Section				60
	5. Effluent return to Thames			20	
	6. Transfer to Great Ouse			20	
COLNE (THAMES)	1. Transfer from remainder of Thames area		75		
	2. Net new requirement in Section				45
	3. Effluent return to Thames			30	
LONDON	1. Transfer from Thames area		125		
	2. Transfer from Upper Lee (Cobbins Brook Reservoir)		15		
	3. New requirement in Section				140
UPPER LEE	1. Cobbins Brook Reservoir	40			
	2. Transfer to London Section			15	
	3. Transfer from Colne (Thames) Section		15		
	4. Transfer from Great Ouse		30		
	5. New requirement in Section				70
SOUTH ESSEX	1. Transfer from Thames (via new tunnel)		110		
	2. New requirement in Section				110
NORTH ESSEX	1. Transfer from Great Ouse		65		
	2. New requirement in Section				65
REMAINDER OF THAMES AREA	1. Yield of ground-water development in Chalk and Oolite	200			
	2. Transfer from Avon or Test or import from Severn	95			
	3. Net new requirement in area (gross 185 m.g.d.)				NIL
	4. Transfer to Bucks Section			20	
	5. Transfer to Colne (Thames) and Upper Lee Sections			90	
	6. Effluent return from Bucks and Colne (Thames) Sections		50		
	7. Transfer to London Section			125	
	8. Transfer to South Essex Section (including 20 m.g.d. now authorised)			110	
REMAINDER OF GREAT OUSE AND WELLAND AND NENE AREAS	1. Yield of ground-water development in chalk area (including recharge of direct run-off or storage in Great Bradley Reservoir)	155			
	2. Abbotsley Reservoir (Great Ouse)	30			
	3. Empingham/Manton pumped storage reservoirs	50			
	4. Transfer from Bucks Section		20		
	5. Requirement in area				100
	6. Transfer to Northampton Section (excluding 12 m.g.d. now authorised)			60	
	7. Transfer to North Essex Section			65	
	8. Transfer to Upper Lee Section			30	
TOTALS:		650			650

In presenting Table L we would stress the point made on page 53 i.e. that this simplified balance sheet is not intended to be a blueprint of the actual pattern of water distribution thirty-five years hence and cannot be used to measure the utility of local pipelines or other engineering works which are planned for execution during the next few years. (see 8.6 'Delivery Network').

The transfer proposals outlined above for 1971, 1981 and 2001 are illustrated diagrammaticelly in Figs. I, II and III.

8.4 Capital Expenditure

The dates by which completion of schemes might he required on the progrsmme we have outlined above are indicated in Fig. IV. The choice of schemes is to some extent arbitrary and in particular we have not heen ahle to compare the relative merits of furtber surface storage in the Thames Valley with the storage of Thames water in the Lee Valley (Cohbins Brook Reservoir).

Table M lists future works required in the central area, together with estimates of their cost, the accumulated total cost to the year 2001 and, taking into account the dates hy which each scheme may he required, the present velue of the estimated future expenditures (assuming 6½ per cent. interest).

We would atress tbat the sequence of development may be falsified hy events hut even so the suggested overall expenditure and equivalent present value are likely to be of the right order if the estimated demands materialise.

Table M shows that tbe total cost of further conservation and delivery works proposed for the central area to the year 2001 is estimated et ahout £310 million with a present value of ahout £140 million (hoth st 1966 prices). These amounts do not include contingent capital outlay, such as that for power production for pumping.

Over the remainder of the region, further expenditure on a variety of local and area schemes will he required. We estimate they will cost, in total, ahout £100 million. In addition, expenditure on local distribution works will he incurred throughout the region, hringing the estimated total outlay for all water supply works (excluding farm storage and other works on private premises) in the region to about £750 million during the remainder of this century.

8.5 Comparison with Wash Barrage

The deficiency for the central area shown in line 5 of Table H for the year 2001 is comparahle with the yield estimated for the Wash harrage scheme outlined in the Report on the Water Resources of the Great Ouse Basin. However, since that scheme could not he completed until the early 1980's it would first he necessary to complete a variety of other schemes including a substantial development of the Thames and Great Ouse ground-water schemes and one of the msjor pumped storage schemes referred to in Table K. We bave assumed that the pre-1981 costs indicated in Tsble M would tberefore be incurred hefore a Wash reservoir could come into operation.

The Report on the Water Resources of tbe Great Ouse Basin referred to a Vash barrage scheme which could provide ahout 620 m.g.d. of water, treated ınd delivered to points tifty miles from tbe Wasb and at an elevation 400 ft. ıbove O.D., for a capital outlay of £287 millions. This supply, which would ɔe available for 'export' from the Wash catcbments, would he additional to any quantity recirculated by normal use witbin tbose catchments.

The increment of demand within the Wash catchments amounts to ahout 130 m.g.d.* hetween 1981 and 2001, of which some 50 m.g.d. has heen estimated as net industrial use, the remaining 80 m.g.d. being returned to storage in

---

* *Table G (page 54): Northampton Section plus*
Table G (page 54): Bucks Section (Great Ouse area) plus
Table H (page 55): line 4.

TABLE M

ESTIMATED INCIDENCE OF CAPITAL EXPENDITURE ON INLAND SCHEMES TO MEET DEFICIENCIES IN THE CENTRAL AREA - 1966 TO 2000

SCHEME	Approx. total increment of yield m.g.d.	Estimated Expenditure in Million Pounds (£M)								Total Capital Expenditure 1966-2000 £M	Present Value of Total Expenditure £M	REMARKS
		Before 1981				After 1981						
		1966-70	1971-80	Total	Present Value	1981-90	1991-2000	Total	Present Value			
1. Authorised schemes (includes Diddington, Wraysbury, Datchet, Farmoor, etc.)	130 (i)	30.0 (ii)	2.5	32.5	26.9	–	–	–	–	32.5	26.9	Works (excluding trunk mains) authorised but not yet in service
2. Local schemes	15 (iii)	8.0	8.0	16.0	11.3	–	–	–	–	16.0	11.3	The 15 m.g.d. permenent addition to yield relates to bores for the Peterborough area
3. Diddington (Brownshill Staunch Intake)	15 (iv)	4.7	–	4.7	4.0	–	–	–	–	4.7	4.0	Yield becomes incorporated in the yield claimed for Abbotsley
4. Ely Ouse to existing storage in Essex	22 (iv)	8.5	–	8.5	7.3	–	–	–	–	8.5	7.3	Yield becomes incorporated in Great Ouse ground-water
5. Great Ouse ground water	155	1.0	28.0	29.0	15.7	11.5	–	11.5	3.3	40.5	19.0	
6. Thames ground water	200	3.4	10.6	14.0	8.5	8.5	–	8.5	2.4	22.5	10.9	
7. Welland and Nene surface storage – (Empingham/Manton)	50	–	7.0	7.0	3.7	5.5	5.5	11.0	2.4	18.0	6.1	
8. Great Ouse surface storage (Abbotsley and Whitchurch)	60	–	–	–	–	17.5	–	17.5	5.0	17.5	5.0	
9. Thames surface storage in Bucks. (Waddesdon)	50	–	–	–	–	19.5	–	19.5	5.5	19.5	5.5	
10. Thames/Lee surface storage (Cobbins Brook)	40	–	20.0	20.0	10.6	–	–	–	–	20.0	10.6	Includes new Thames/Lee tunnel main.
11. Imported water to Thames from Avon & Dorset and/or Severn	95	–	–	–	–	–	35.0	35.0	5.3	35.0	5.3	No differentiation made at this stage between costs of alternative sources
12. Successive re-use	215	0.7	3.3	4.0	2.4	5.1	6.5	11.6	2.4	15.6	4.8	Includes abstraction treatment and pumping after initial use in Thames and Ouse
13. Trunk mains and service reservoirs	–	9.5	19.0	28.5	18.2	14.0	17.5	31.5	6.6	60.0	24.8	Mains from surface storage or regulated river to distribution centres
Totals (rounded)	1000	65	100	165	110	80	65	145	30	310	140	Totals show increase in yield and expenditure over existing 1965

Notes:- *(i) The gross yield of authorised schemes is about 150 m.g.d. The difference of 20 m.g.d. is assumed to be absorbed in subsequent major developments.*

(ii) Includes approximately £13M for works either completed or under construction.

(iii) The gross yield of local schemes is about 30 m.g.d. The excess over 15 m.g.d. is assumed to be absorbed in subsequent major developments.

(iv) Yield not carried to total.

the barrage. This re-circulating quantity would evidently be added to the net yield of 620 m.g.d. to provide for a total use of about 700 m.g.d. if this Wash scheme were to be constructed to meet requirements materialising between 1981 and 2001.

The first stage development of the barrage scheme outlined in that Report would give an 'export' yield from the Wash catchments of about 400 m.g.d. and taking into account this 'recirculation' it would provide about 480 m.g.d. The disposition of resources outlined in the earlier part of this chapter (e.g. Table L) depends upon 100 per cent re-use (i.e. one further use) of the water provided to meet public water supply deficiencies in the Thames Basin upstream of Teddington Weir (185 m.g.d. in 2001). Under these circumstances the increment of net deficiency to be met between 1981 and 2001 is estimated at 380 m.g.d. (Table H line 5). Provided that 125 m.g.d. is obtained from the Thames controlled ground water abstraction scheme, this pattern of re-use could be reproduced in 2001 by supplying all post-1981 deficiencies in the Bucks Section directly from the Wash and in addition by discharging 40 m.g.d. of water from the Wash into the River Thames for the benefit of the Thames and its dependent areas (Colne (Thames) and London Sections). The remainder of the central area would be supplied direct from the Wash. This pattern of supply, which is illustrated in Fig. V, calls for the same increase in resources (380 m.g.d.) as that indicated in Table H, line 5 and in Table L.

Even without taking into account the possibilities of regulating the Thames and other rivers by means of the storage provided in the Wash, it is probable that the first stage Wash development would exceed requirements in 2001. This factor hinders any direct comparison between that proposal and those pertaining to conventional sources. The further possibilities of the fully developed Wash scheme, including its use for regulation of the River Thames, etc. and possibly a supplementary input of water to the Wash from the Trent are obviously very great indeed - probably exceeding a yield of 1000 m.g.d.

We have nevertheless attempted a comparison between the series of conventional schemes and a Wash project having a comparable 'export' yield of 300 m.g.d. (380 m.g.d. effective yield including internal recirculation) using the cost data given for the barrage in the Report of the Water Resources of the Great Ouse Basin.

From data given in that Report we have assessed the headworks cost of a barrage scheme to provide a reliable 'export' yield of 400 m.g.d. at £134 million. We have assumed that, following the development of 80 m.g.d. of ground-water export from the Ely Ouse catchment and of local storage for irrigation in the barrage catchment, such a scheme would, in fact, yield only 300 m.g.d. for export and 380 m.g.d. altogether in 2001. Treatment works with a capacity of 450 m.g.d. for an output of 380 m.g.d. would cost about £26 million and pumps and pumping stations a further £10 million giving a total capital expenditure of £170 million excluding trunk mains and service reservoirs. We consider that one or more of the existing fenland channels (the New Bedford River, the Ely Ouse or the Cut-off Channel) could be adapted to convey water from the Wash Barrage to the intake points near Brownshill Staunch and Ely referred to in connection with conventional schemes. If this were done, the trunk mains and service reservoirs required to effect the distribution shown in Fig. V, and to reach the notional delivery points and elevations used previously for Tables G and J, are estimated to cost £74 million over and above the cost of the trunk mains and service reservoirs to be provided before 1981. Thus the total capital expenditure required after 1981 would be about £244 million.

The dates by which the completion of the works required between the present day and 2001, incorporating a Wash barrage project to meet post-1981 deficiencies, are shown in Fig.VI and the estimated costs and present values of those works are given in Table N. This may be compared with Table M which related to the alternative series of inland schemes.

The total cost during this century, if needs after 1981 are to be met from a Wash barrage is estimated to exceed that from the alternative series of inland schemes by about £90 million, i.e. by about 30 per cent. However, because the Wash barrage would involve very heavy capital outlay concentrated into a single decade before yielding any supplies, the corresponding present value in Table N exceeds that in Table M by about £70 million or just over 50 per cent.

These comparisons show a substantial financial advantage for the more conventional types of scheme. It should also be remembered that the operating costs of the barrage scheme are likely to be rather higher than those for inland conservation works and the quality of the water somewhat inferior; the greater hazards of barrage construction and the consequent uncertainty of estimates should also be borne in mind.

On the other hand, we have taken no cognizance of the other benefits accruing from the barrage proposal - e.g. in communications, land reclamation, coast protection, reduction of expenditure on land drainage and tidal outfalls, etc. - and by taking no account of the possibilities of river regulation by water from the barrage we have greatly understated its possible yield.

Because of this, and because the successful development of most or all of the inland schemes considered suitable for development cannot be taken for granted, we consider that a feasibility study and cost/benefit investigation of the Wash barrage should be undertaken. On completion of the study fuller information about the proposed inland schemes should also be available and a rigorous comparison of costs and benefits should then be undertaken.

We consider it vital, however, that a study of the possibilities of storage in the Wash should not be made a pretext for delay in the investigation of the various inland schemes - both surface and underground - and in the development of those schemes which will be needed to meet demands during the next fifteen or twenty years.

8.6 Delivery Network

The pattern of regional water supply which has been discussed in this chapter would require the development of a network of aqueducts and regulated reaches of rivers on the lines illustrated in Map 7 and Figs. I, II and III. It also presupposes the availability of this network for routing supplies in various directions from time to time in order to make the most effective use of the source works developed at the time.

Whilst a network of the kind illustrated would clearly lend itself to a regional solution of the water problem - and is indeed essential to any such solution - it is not to be supposed that the individual elements of the network can be decided upon or sized at this date to match some particular pattern of distribution (such as that shown in Table L) which might obtain at the end of the century. However, regard should be had to the longer term shaping of the system, from time to time, as works are added to meet more immediate needs.

Although long-distance routing of water necessarily increases the cost of the supply to most users such a network has certain compensating advantages in that any single source works can be utilised fully soon after completion

TABLE N

ESTIMATED INCIDENCE OF CAPITAL EXPENDITURE FOR ALTERNATIVE SCHEMES INCORPORATING A BARRAGE ON THE WASH TO MEET DEFICIENCIES IN THE CENTRAL AREA - 1966-2000

SCHEME	Approx. total increment of yield m.g.d.	Estimated Expenditure in Million Pounds (£M)								Total Capital Expenditure 1966-2000 £M	Present Value of Total Expenditure £M	REMARKS
		Before 1981				After 1981						
		1966-70	1971-80	Total	Present Value	1981-90	1991-2000	Total	Present Value			
1. Authorised schemes (includes Diddington, Wraysbury, Datchet, Farmoor etc.)	130 (i)	30.0 (ii)	2.5	32.5	26.9	–	–	–	–	32.5	26.9	Works (excluding trunk mains) authorised but not yet in service
2. Local schemes	15 (iii)	8.0	8.0	16.0	11.3	–	–	–	–	16.0	11.3	The 15 m.g.d. permanent addition to yield relates to boreholes for the Peterborough area
3. Diddington (Brownshill Staunch Intake)	15	4.7	–	4.7	4.0	–	–	–	–	4.7	4.0	
4. Ely Ouse to existing storage in Essex	22	8.5	–	8.5	7.3	–	–	–	–	8.5	7.3	
5. Great Ouse Ground water	90	1.0	28.0	29.0	15.7	–	–	–	–	29.0	15.7	
6. Thames Ground water	125	3.4	10.6	14.0	8.5	–	–	–	–	14.0	8.5	
7. Welland & Nene Surface Storage: Empingham Resr.	20	–	7.0	7.0	3.7	–	–	–	–	7.0	3.7	
8. Wash Barrage	380	1.0	145.0	146.0	78.1	12.0	12.0	24.0	5.2	170	83.3	Costs cover all works except for trunk mains and service reservoirs (see 10)
9. Successive Re-use	215	0.7	3.3	4.0	2.4	5.1	6.5	11.6	2.4	15.6	4.8	Includes abstraction, treatment and pumping after initial use in Thames and Ouse areas
10. Trunk mains and service reservoirs (iv)	–	9.5	43.0	52.5	31.0	25.0	25.0	50.0	10.9	102.5	41.9	Mains from surface storage or regulated river to distribution centre
Totals (rounded)	1000	65	245	315	190	40	45	85	20	400	210	

NOTES:- *(i) The gross yield of authorised schemes is about 150 m.g.d. The difference of 20 m.g.d. is assumed to be absorbed in subsequent major developments.*

(ii) Includes approximately £13M for works either completed or under construction.

(iii) The gross yield of local schemes is about 80 m.g.d. The excess over 15 m.g.d. is assumed to be absorbed in subsequent major developments.

(iv) The estimated expenditure of £74M for trunk mains and service reservoirs required for the Wash Barrage scheme has been allocated as follows:- £24M in the period 1971/80. £25M in 1981/90 and £25M in 1991/2000.

and, because of the variation in rainfall throughout the region, the reliable yield of the combined sources will exceed somewhat the sum of their individual reliable yields. These advantages accrue provided that the delivery network can be used flexibly as circumstances require.

The network - of which a considerable part already exists or is under construction - is likely to be situated within the areas of five or six river authorities and about a dozen major water supply undertakings. The links shown in the diagrams may well be substantially complete within a decade or so and during that time consideration should be given to the means whereby co-ordinated control of the network may be achieved.

In bulking together the deficiencies of different users in each part of the region we have neglected the conflict which might arise between the demand for untreated supplies - especially for power stations and irrigation - and for treated supplies. Much of the network might contain untreated water, or water which has had only sufficient treatment to limit maintenance costs on the pipelines, but certain parts of the network are already being used to convey treated water. Fig. VII indicates those links which are likely to form a treated water system and those - including the principal river links - which will contain untreated water.

In estimating the costs of the works required throughout the region, allowance has been made for treatment of all supplies to potable standard. After allowing for pre-treatment of piped raw water and perhaps for duplicate delivery lines at certain places an appreciable saving on the estimated treatment works costs may therefore be possible.

The treated water portion of the 'ring main' is likely to comprise essentially the delivery mains of the Great Ouse Water Authority and of the Colne Valley, Lee Valley and Rickmansworth and Uxbridge Valley Water Companies. Some of these are now being designed or constructed and subsequently duplicate links will have to be added; in some instances only an acceleration of existing plans for duplication will be required. A new link, designed for flows in either direction, will be required between Amptbill Reservoir and Buckinghamshire, probably with a capacity of 10-12 m.g.d. initially and subsequently with twice that capacity. Alternatively instead of increasing the capacity of this link, a direct raw water link could be completed between the Bucks and Northampton sections (making use of any raw water intake main from the Great Ouse to the Bucks reservoirs) and deliveries between these areas and the Great Ouse area (Fig. III) would be rerouted accordingly. These alternatives will require detailed examination in the light of reservoir site inveatigations and local development of demand.

The proposed intake tunnel from Brownshill Staunch to Diddington/ Abbotsley Reservoirs will probably suffice for needs until the year 2001. Intake pipelines from the Ely Ouse to the head of the Stour and corresponding intake capacity to Abberton and Hanningfield Reservoirs will have to be of large capacity initially to carry intermittent input and may well be suitable, with little modification, for the heavy continuous flows of later years.

One of the most important links in the network will be that from the River Thames at Hampton to the Lee Valley near Lockwood and perhaps thence to Hanningfield Reservoir. The existing tunnel of the Metropolitan Water Board will probably suffice for this purpose until about 1981; after that date, however, a second tunnel will probably be required especially if large intermittent inputs have to be conveyed to Cobbins Brook Reservoir.

8.7 Siting of Power Stations on Aqueducts

The allowances made in Table C (Chapter 4) would cover evaporation losses for about six power stations of 2000 MW capacity (with recirculatory cooling) in 1981 and the equivalent of fourteen such stations in 2001. We are advised by representatives of the Central Electricity Generating Board that this capacity will have to be sited inland, in addition to other stations on the coast and estuaries, and that it would be beneficial if some of it could be located close to the heavy demands of the London Basin and the areas immediately north and west of London. It might be economic for them to take water from aqueducts at points some distance from the source.

The peak water abstraction of a 2000 MW station could be about 30 m.g.d., of which half would be returned. The effluent would have increased dissolved salts but would be thoroughly aerated. Consideration should, therefore, be given to the practicability of supplying one or more of the stations with water from that part of the delivery network provided for major raw water transfers or from major sewage outfalls.

CHAPTER 9. SUMMARY

9.1 Area of Study

This study covers the areas of eight river authorities in south east England, and the areas of the London Excluded Area, the Thames Conservancy and the Lee Conservancy Catchment Board. The areas are:

Welland and Nene
Great Ouse
East Suffolk and Norfolk
Essex
Lee
Thames (including London Excluded Area)
Kent
Sussex
Hampshire
Avon and Dorset

9.2 Population

The population of the study area at various dates has been estimated as follows:-

TABLE P

ESTIMATED POPULATION

millions

1964	1971	1981	2001
19.1	20.5	22.3	27.9

9.3 Public Water Supply: Resources, Demands and Effective Deficiencies

The authorised rssources of the 131 statutory water undertakings in the study area, their estimated demands (for metered and unmetered aupplies) at various dates and the effective deficiencies which will have to be met are given in Tahle Q.

Two points deserve note:-

(i) The demand figure given for tbe year 2001 is the lowest which is likely to apply at the date, unless the population forscasts prove to he radically wrong: the earlier demand figures are thoss for which we must make realistic provision in tbe next few years.

(ii) The estimates of effective deficiencies take account, on the one hand, of the possibilities of successive re-use of water along certain rivers and, on the other hand, of the impossibility of transferring csrtain surpluses to other users; hence tbey do not equal the difference between expected demand and the authorised resources of 1,300 m.g.d. (see 2.6 on page 10).

TABLE Q

AUTHORISED RESOURCES, DEMANDS AND EFFECTIVE DEFICIENCIES OF STATUTORY WATER UNDERTAKINGS

to nearest 10 m.g.d. - annual average

Authorised resources	1964		1971		1981		2001	
	Demand	Effective Deficiency	Demand	Effective Deficiency	Demand	Effective Deficiency	Demand	Effective Deficiency
1,300	1,020	–	1,250	80	1,580	310	2,220	860

9.4 Direct Industrial Demand

In addition to the demands for public water supply we consider that allowance should be made for the net consumption (i.e. the abstraction of water not returned in a suitable place or condition to permit re-use) by direct industrial (private and public) users of the following amounts:-

TABLE R

ESTIMATED DIRECT INDUSTRIAL DEMAND

to nearest 5 m.g.d.

1965	1965	1971		1981		2001	
Gross Use	Net Use	Net Use	Increase over 1965	Net Use	Increase over 1965	Net Use	Increase over 1965
700	165	190	25	265	100	390	225

9.5 Spray Irrigation - Effective Demand

The best estimate that we can make of the likely use of water for spray irrigation is shown in Table S.

TABLE S

EFFECTIVE DEMAND - SPRAY IRRIGATION

million gallons

	1965	1971	1981	2001
Seasonal use in year of peak demand	17,000	23,000	29,000	35,000
Average day in year of peak demand	50	60	80	100
Peak daily use	270	370	460	560

We consider that most of this demand will be met by the development of local farm storage or the use of ground water, a total of some 30,000 million gallons of storage being brought into use for this purpose by 2001, most of it being artificial storage above ground.

Excepting in the Essex and Lee areas, to which water will probably have to be imported for the irrigation of high value crops, we have assumed that the needs of spray irrigators will not materially affect the analysis of public water resources which has been made in this study. The needs of the Essex and Lee areas, assuming that water is imported uniformly throughout the year for storage locally, do not add significantly to the overall daily needs. These needs are shown in Table T.

9.6 Overall effective future deficiencies

Table T shows the overall effective future deficiencies for the south east region, the quantities being derived from Tables Q and R.

TABLE T

OVERALL EFFECTIVE FUTURE DEFICIENCIES

to nearest 100 m.g.d.

1971	1981	2001
100	400	1,100

9.7 Potential Resources

Particulars of some one hundred and thirty schemes for the development of new sources have been submitted to us and are shown in Appendix IV. It has not been possible to review these in detail. Some have been thoroughly studied by their sponsors; others have had very little study; but for each source listed there is a prima facie case for further investigation in the light of future demands and the outcome of other investigations. In our recommendations, we recommend some of these schemes for construction to meet imminent needs, others for immediate investigation and others for deferment.

9.8 Division of Study Area

In Chapter 7 we examined the individual balance of each river authority area. We have found it convenient to consider the following five areas separately from the remainder of the south east region:

East Suffolk and Norfolk (excepting the Ipswich and south east Suffolk area),
Kent (outside the limits of supply of the Metropolitan Water Board),
Sussex,
Hampshire,
Avon & Dorset.

These areas will be able to meet their needs from a variety of internal sources and, without seeking to anticipate the statutory surveys of these river authorities under section 14 of the Water Resources Act 1963, we have tried to give some indication of the lines which future development might take.

The last three of the five areas may be able in due course to export water to other parts of the region but in each case major investigations would be required and we do not anticipate substantial transfers from these areas within the earlier part of the period studied.

9.9 Central Area

In Chapter 8 we analysed the needs of the remainder of the study area - the 'central area' - as a single regional problem. The crux of this problem is the 'deficiency zone', with heavy future needs and inadequate indigenous resources, stretching from Northamptonshire to the coast of Essex. The resources to meet its needs may most readily be found in adjacent parts of the Welland and Nene, Great Ouse and Thames areas.

The new resources required to meet the net future demands of the central area (see Map 7) after allowing for certain new local sources and for the re-use of water are shown in Table U.

TABLE U

MAJOR NEW RESOURCES REQUIRED FOR CENTRAL AREA

m.g.d.

	1971	1981	2001
New Resources	85	270	650

We have examined the possibility of meeting these needs by developing a pattern of sources throughout the central area, principally schemes of controlled ground-water development and pumped storage reservoirs and we have compared the likely costs of supplying various Sections of the deficiency zone from a number of these sources. These sources appear to be capable of meeting most of the needs of the region during the remainder of the century provided that they are supplemented in the last decade by transfer from the Severn Basin and/or from the Sussex, Hampshire and Avon and Dorset areas into the River Thames.

Prima facie this appears to us to be the most economic and beneficial way of meeting the water needs of south east England and we have accordingly outlined a programme of integrated development of these sources. Priority is given, both on economic grounds and because of the frequent objections to the use of land for reservoirs, to the development of controlled ground-water abstraction. Much has to be learned about this, however, and we recommend appropriate programmes of investigation for these schemes as well as investigation of certain pumped storage sites.

9.10 Wash Barrage

We have outlined an alternative way of meeting estimated needs in the central area by substituting a Wash freshwater storage project for all the schemes which would otherwise come into operation after 1981. We have adopted the cost estimates for this scheme shown in the Report on the Water Resources of the Great Ouse Basin for purposes of comparison between the barrage scheme and inland schemes to supply the central area. It should be borne in mind however, that the smallest Wash scheme for which costs have been estimated would yield considerably more than is required for a direct comparison (especially if allowance is made for the possible use of the Wash storage to regulate the Thames and other rivers). Moreover, no allowance has been made for other benefits of a Wash barrage.

The capital cost of developing the necessary conservation works, treatment works and principal delivery facilities to service storage centres in each section of the deficiency zone and the remainder of the central area has been

estimated and, to take account of the future incidence of capital outlays, tbe estimated costs bave heen converted to equivalent present values. Tahle V abows tbe estimates for the wbole period to the year 2001.

TABLE V

ESTIMATED COSTS OF HEADWORKS AND BASIC DELIVERY NETWORK
(CENTRAL AREA ANALYSIS)

£ million

	Capital outlay	Present value
(a) Combination of inland schemes	310	140
(b) Pattern incorporating Wash project	400	210

Clearly (a) is materially chsaper, especially when ths early heavy incidence of cost on tbe harrage project is taken into account. Nevertbeless we consider tbat the Wash project merits further investigation not only because of ths uncertainties surrounding some inland schemes but slso because demands at the end of the century may consaiderably exceed the estimates.

9.11 **Other unconventional sources**

We do not considsr that otber ways of meeting requirements would bear cost comparison with tbe proposals included in our recommendations although small desalination units to meet peak demands in some coastal localities might prove justifiable.

9.12 **Regional delivery network**

We would draw attention to the regional delivery network wbich will necessarily develop if our proposals are carried out and to tbe need to prepare for the unified and flexible operation of tbis network if the full benefits of an integrated regional reaources pattern are to be realised.

CHAPTER 10. RECOMMENDATIONS

10.1 Introduction

Our rscommendations relate primarily to the central area of the region (incorporating tbe deficiency zone) which wae reviewed in Chapter 8. These recommendations are listed in 10.2.

Proposals for schemes in the remainder of the region are not dealt witb in tbat Chapter but they are included under the respective river authority areas in Chapter 7. These schemes muat be conaidered on tbeir merits by the authorities concerned, hut our recommsndations in 10.3 indicate tbe principal means by which the demands outsids ths central area of tbe region could be met.

Some general recommendations are made in 10.4.

10.2 Centrnl Area

We rscommend:-

(i) Works to he undertaken

(a) the expansion to their full capacity of tbe works of tbe Great Ouse Water Authority at Diddington Reservoir should he put in band at an sarly date and the proposal for the construction of a supplementary intake to that ressrvoir from tbe Great Ouse should be procesded with urgently;

(b) the scheme for pumping surplus water from the Great Ouse catchment into tbe headwaters of the River Stour and rivers in Eesex should he investigated hy the rivsr authorities concerned and steps should be taken to put that scheme into effect at the earliest possible date and to provids appropriately increased intaks capacities at Abberton and Hanningfield Reservoirs;

(c) Datcbet Reservoir should he constructed as aoon as possihle, as planned hy the Metropolitan Water Board;

(d) the construction of intake works near Sunnymeads on tbs River Thames and the necessary pipslines to help meet increased demands on the Colne Valley Water Company, Rickmansworth and Uxbridge Valley Water Company and the Lee Valley Watsr Company should proceed, notwithatanding tbat it may he necessary, if a severe drought should occur in ths early 1970s, to reduce the flow over Teddington Weir helow the statutory minimum of 170 m.g.d. All possihle ateps sbould be taken, bowsver, to minimise that risk;

(e) the ground-water resources in tbe Peterborough area and adjoining parts of the Lincolnshire River Authority area should be developed to keep pace with requirements in that locality;

(f) certain local scbemes will aleo bavs to he undertaken in Essex and East Suffolk which could help to relieve the short-term deficiencies of those areas. We consider that they should receive urgent investigation and consideration and tbat no ohstacle should he put in the way of their development if a sound local case can be made for tbem.

(ii) Ground-water investigations

(a) pilot work on the Thames Conservancy controlled ground-water scheme, for which some preparatory work has alresdy heen done, should be put in hand as a matter of urgency and completed as expeditiously as possihle;

(h) the Greet Ouae River Authority sbould forthwith put in hand investigations (including a pilot scheme) on the controlled development of ground water in the Great Ouse Basin and prosecute the work in parallel with the Thames Conservancy's scheme;

(c) the Water Resources Board and the sppropriate river authorities should study the possihilities of ground-water storage in other areas, such as the catchments of the Avon and Test, which may need to he utilised in the future for the assistance of the central area, hut major pilot schemes in these aress can he deferred pending the results of the inveatigations in the Thames and Great Ouse areas.

(iii) Site survey and exploration

Topographic survey and site investigation should be put in hand at the reservoir sites detailed helow so tbat celculation of storage potentials and of probahle construction costs can be completed:

(a) hy the end of 1967

Empingbam	-	Welland and Nene scheme 10 (Appendix IV)
Manton	-	Welland and Nene scheme 10
Waddesdon	-	Thames scheme 16
Whitchurch	-	(Great Ouse scheme 17 (Thames scheme 16
Great Bradley	-	Great Ouse scheme 16

(h) hy tbe end of 1969

Abhotsley	-	Great Ouse acheme 14
Cobbins Brook	-	Lee scheme 2

In addition, tbe following sites may require investigation in the light of results ohtained at the sites listed at (a) and (h) ahove

Bampton	-	Thames scheme 18
Enhorne	-	Thames scheme 18
Otmoor	-	Thames scheme 18

Only preliminary hydrological investigetions have heen made in respect of the Bampton, Cohhins Brook, Enborne, Otmoor and Waddesdon sites and we anticipate that river authorities will carry out thorough hydrological studies of them, singly snd in combination, when preparing the parts of their section 14 surveys whicb relate to the resources of their areas.

(iv) Wash Barrage

A feasibility investigation and cost/benefit study of the Wash Barrage project should be put in hand immediately so that consideration of the project can be included in a general review of regional storage schemes in the early 1970's.

10.3 Areas outside Central Area

Generally, river authorities will develop local sources within their areas as described in Chapter 7. Investigation and study of appropriate schemes will have to be carried out well before the dates by which demands are likely to exceed authorised resources. In particular, we consider that:

(i) Remainder of Kent Area

(a) the River Medway should be developed as the principal source for the western and northern parts of the area;

(b) further investigation should be given to pumped storage/regulating reservoir sites on the Rivers Rother and Stour;

(c) local ground-water schemes can be developed to meet some demands in the eastern part of the area;

(ii) Hampshire Area

The Itchen and Test catchments should be developed to meet demands in the Portsmouth/Southampton area by ground-water regulation of the rivers, pumped storage reservoirs, or a combination of the two;

(iii) Remainder of East Suffolk and Norfolk Area
Sussex Area
Avon and Dorset Area

The resources of these areas are ample for their foreseeable needs. Ground-water is likely to remain of primary importance in these areas and the possibilities of controlled use of underground storage should be borne in mind for future developments. Additional conventional development of ground-water use is likely to be acceptable in many localities, however, and there are also opportunities for pumped storage of surface run-off.

10.4 General Recommendations

(i) A study should be made of the problems involved in the successive re-use of water.

(ii) A review should be made of the Metropolitan Water Board's powers of abstraction from the River Thames to clarify the position vis-a-vis other potential abstractors from that river, and the existing statutory requirements of flow at Teddington Weir.

(iii) The Water Resources Board should make a detailed study of the problems which will arise in operating a regional delivery network (see 8.6) which would enable various combinations of source works to be exploited to the maximum general advantage.

(iv) The Water Resources Board and the appropriate river authorities should give further study to the prohlems of supplementing the flow of the River Thames hy the transfer of water from the River Severn.

(v) River authorities and statutory watsr undsrtakers should discuss with local plsnning suthorities the possihility of reserving potential reservoir sites in development plans; they should alao co-operate with local planning authorities at all planning stages of major storage schemes with the view to developing rsservoirs as recrestional centres within ths proposed country parks.

APPENDIX I

Appendix I

Water Supplies in South East England - Demands and Deficiencies (Statutory Water Undertakings)

SUMMARY TABLE. Demands and effective deficiencies in each river authority area and sum of deficiencies to be met throughout the region

River Authority Area	Average Daily Demand – m.g.				Effective Deficiencies on Authorised Resources – m.g.d.		
	1964	1971	1981	2001	1971	1981	2001
Welland & Nene	29	41	74	119	–	30	75
Great Ouse	49	71	107	171	15	30	65
East Suffolk & Norfolk	31	40	56	92	–	10	30
Essex	90	121	154	222	30	80	150
Lee	125	145	170	212	–	20	85
Total demands and deficiencies (rounded to nearest 5 m.g.d.)	325	420	560	815	45	170	405
Thames & London Excluded Area (rounded to nearest 5 m.g.d.)	460	520	615	800	10	55	185
Kent	86	110	141	209	5	20	85
Sussex	50	61	75	105	5	10	35
Hampshire	65	90	122	194	10	45	115
Avon & Dorset	35	47	60	95	–	5	35
Total demands and deficiencies (rounded to nearest 5 m.g.d.)	235	310	400	605	20	80	270
Grand Totals (rounded to neerest 10 m.g.d.)	1,020	1,250	1,580	2,220	80	310	860

NOTES: (i) *Effective deficiencies on authorised resources allow for available imports under existing arrangements and, where appropriate, for the re-use of sewage effluents.*

(ii) *Thames deficiencies are based on the estimated demands of those undertakings producing effluent which is discharged to the river above Teddington Weir. These deficiencies are larger than the corresponding ones of undertakings producing effluent which is discharged below the weir. By providing in full for the 'upstream' deficiencies, quantities equal to the difference between the 'upstream' and 'downstream' deficiencies (i.e. 5 m.g.d. in 1971 35 m.g.d. in 1981 and 135 m.g.d. in 2001) would be made available for export re-use. The total deficiencies given in the above table therefore exceed the minimum totals required from new conservation works by these amounts.*

Welland and Nene

TABLE I. Demands, resources, surpluses and deficiencies of statutory (ii) water undertakings within Welland and Nene River Authority Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
10	Higham Ferrers & Rushden W.B.	1.2	1.4	1.7	2.6	1.4	1.4	–	–	0.3		1.2	
8	Kesteven W.B.	0.2	0.3	0.4	0.5	–	–		0.3	0.4		0.5	
9	Leicester C.B.C.	0.8	0.9	1.4	2.1	0.7	0.7		0.2	0.7		1.4	
11	Mid-Northamptonshire W.B.	14.5	22.0	44.0	70.0	12.3	12.3		9.7	31.7		57.7	
16	Nene & Ouse W.B.	1.2	1.4	2.0	3.0	1.5	1.9	0.5		0.1		1.1	
2–7	Peterborough B.C. (i)	5.5	7.8	14.2	24.2	7.5	8.5	0.7		5.7		15.7	
1	South Lincolnshire W.B.	4.1	5.4	7.9	11.8	7.1	7.1	1.7		0.8		4.7	
23	Wisbech & District W.B.	1.6	1.9	2.8	4.3	–	–		1.9	2.8		4.3	
	Total	29.1	41.1	74.4	118.5	30.5	31.9	2.9	12.1	–	42.5	–	86.6

NOTES: (i) *Peterborough B.C. figures include Old Fletton(4), Whittlesey(3), U.D.C.s and Norman Cross(5), Peterborough(7) and Thorney(2) R.D.C.s.*

(ii) *Corby W. Co. demands have been included in the table of industrial use as the demands relate solely to the Corby Works of Stewarts and Lloyds Ltd.*

TABLE II. Imports

	Average Daily Transfer – m.g.		
	1971	1981	2001
Kesteven W.B. from Lincs area	0.3	-	-
Mid-Northamptonshire W.B. from Great Ouse area	9.7	12.0	12.0
Nene & Ouse W.B. from Great Ouse area	-	0.1	-
Wisbech & District W.B. from Great Ouse area	1.9	-	-
Total transfers into area	11.9	12.1	12.0

TABLE III. Effective Deficiencies

	1971	1981	2001
Effective deficiencies, by deduction of imports from deficiencies in Table I (rounded to nearest 5 m.g.d.)	0	30	75

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within Great Ouse River Authority Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiences (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
12	Buckingham B.C.	0.2	0.4	0.5	1.0	0.3	0.6	0.2		0.1			0.4
13	Bucks W.B.	6.1	8.8	17.4	35.3	3.4	3.4		5.4		14.0		31.9
17	Cambridge W. Co.	7.9	10.6	15.4	23.1	8.2	8.5		2.1		6.9		14.6
27	Docking R.D.C. (i)	0.3	0.5	0.6	0.9	1.0	1.2	0.7		0.6		0.3	
18	Ely, Mildenhall & Newmarket W.B.	3.9	4.9	6.0	8.1	6.6	7.0	2.1		1.0			1.1
26	Freebridge Lynn R.D.C.	0.1	0.1	0.1	0.2	0.3	0.3	0.2		0.2		0.1	
25	Kings Lynn B.C.	4.4	8.0	12.0	16.0	4.0	4.0		4.0		8.0		12.0
69	Lee Valley W. Co.	5.4	7.7	11.1	16.8	6.4	12.4	4.7		1.3			4.4
70	Luton W. Co.	0.6	0.8	1.0	1.3	–	12.0	11.2		11.0		10.7	
14	Mid-Bedfordshire W.B.	6.5	7.0	9.3	17.0	5.4	9.0	2.0			0.3		8.0
11	Mid-Northamptonshire W.B.	–	–	–	–	–	12.0	12.0		12.0		12.0	
16	Nene & Ouse W.B.	2.5	3.3	4.5	6.8	1.8	5.3	2.0		0.8			1.5
15	North Bedfordshire W.B.	4.6	6.4	9.5	15.7	5.0	9.0	2.6			0.5		6.7
24	Swaffham U.D.C.	0.2	0.2	0.2	0.3	0.4	0.4	0.2		0.2		0.1	
22	Swaffham R.D.C.	0.4	0.8	0.9	1.2	1.1	1.1	0.3		0.2			0.1
20	Thetford B.C.	0.4	1.3	1.9	3.0	0.8	1.6	0.3			0.3		1.4
21	Wayland R.D.C.	0.9	1.5	2.7	3.9	0.8	1.2		0.3		1.5		2.7
19	West Suffolk W.B. (ii)	2.5	3.9	6.3	9.1	3.5	3.2		0.7		3.1		5.9
23	Wisbech & District W.B.	3.6	4.9	7.6	11.7	4.6	6.9	2.0			0.7		4.8
	Total m.g.d.	48.5	71.1	107.0	171.4	53.3	99.1	40.5	12.5	27.4	35.3	23.2	95.5

NOTES *(i) Docking R.D.C. demand figures include small supplies to East Suffolk and Norfolk areas.*

(ii) West Suffolk W.B. have one source with a licence which expires in 1969, hence authorised resources are less than present resources.

TABLE II. Imports - Nil

TABLE III. Additional resources arising from re-abstraction of effluent

	1971	1981	2001
Great Ouse Water Authority (Offord Intake)	0	+ 5	+ 30

TABLE IV. Effective deficiencies

	1971	1981	2001
Effective deficiencies by sum of Tables I, II and III (rounded to nearest 5 m.g.d.)	15	30	65

East Suffolk and Norfolk

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within East Suffolk and Norfolk River Authority Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiences (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
48	Aldeburgh B.C.	0.2	0.3	0.4	0.5	0.3	0.3	–	–		0.1		0.2
36	Blofield & Flegg R.O.C.	0.2	0.2	0.3	0.4	0.4	0.4	0.2		0.1		–	–
33	Cromer U.D.C.	0.6	0.7	1.1	1.7	1.0	2.0	1.3		0.9		0.3	
43	Depwade R.O.C.	0.7	0.8	1.0	1.5	0.7	1.0	0.2		–	–		0.5
46	Diss U.O.C.	0.2	0.3	0.4	0.6	0.4	0.4	0.1		–	–		0.2
45	East Anglian W. Co.	10.0	12.5	17.0	31.0	14.3	20.5	8.0		3.5			10.5
40	East Dereham U.O.C.	0.3	0.4	0.5	0.7	0.5	0.5	0.1		–	–		0.2
31	Erpingham R.O.C.	0.5	0.7	0.8	1.1	1.0	1.0	0.3		0.2			0.1
49	Felixstowe & District W. Co.	0.9	1.0	1.1	1.3	2.5	2.5	1.6		1.4		1.2	
41	Forehoe & Henstead R.O.C.	0.2	0.3	0.5	0.9	0.2	0.2		0.1		0.3		0.7
28	Hunstanton U.O.C.	0.3	0.4	0.6	0.8	0.3	0.3		0.1		0.3		0.5
50–53	Ipswich C.B.C. (i)	7.0	10.5	16.2	25.7	8.5	9.0		1.5		7.2		16.7
47	Leiston–cum–Sizewell U.O.C.	0.1	0.2	0.3	0.4	0.1	0.1		0.1		0.2		0.3
44	Loddon R.O.C.	0.3	0.4	0.5	0.7	0.4	0.4	–	–		0.1		0.3
39	Mitford & Launditch R.O.C.	0.1	0.6	0.7	1.0	1.0	1.0	0.4		0.3		–	–
34	North Walsham U.D.C.	0.3	0.4	0.4	0.5	0.4	0.4	–	–	–	–		0.1
37	Norwich C.B.C.	7.7	8.5	11.5	18.5	13.5	19.0	10.5		7.5		0.5	
38	St. Faiths & Aylsham R.O.C.	0.1	0.1	0.2	0.3	0.4	0.4	0.3		0.2		0.1	
35	Smallburgh R.O.C.	0.3	0.4	0.5	0.9	0.6	0.6	0.2		0.1			0.3
32	Sheringham (E. Gas Board)	0.2	0.3	0.4	0.5	0.5	0.5	0.2		0.1		–	–
30	Walsingham R.O.C.	0.4	0.6	0.8	1.2	0.8	0.8	0.2		–	–		0.4
29	Wells–next–the–Sea U.O.C.	0.1	0.2	0.3	0.4	0.1	0.1		0.1		0.2		0.3
19	West Suffolk W.B. (ii)	0.1	0.1	0.1	0.2	–	–		0.1		0.1		0.2
42	Wymondham U.O.C.	0.4	0.5	0.6	1.2	0.7	0.7	0.2		0.1			0.5
	Total m.g.d.	31.2	40.4	56.2	92.0	48.6	62.1	23.7	2.0	14.4	8.5	2.1	32.0

NOTES: *(i) The figures for Ipswich C.B.C. include those for Stowmarket U.D.C.(142), Deben R.D.C.(50), Gipping R.D.C.(52) and Woodbridge U.D.C.(51)*

(ii) West Suffolk W.B. present demands met by transfer from Great Ouse area.

TABLE II. Imports - Nil

TABLE III. Effective Deficiencies

	1971	1981	2001
Effective deficiencies, i.e. deficiencies in Table I (rounded to nearest 5 m.g.d.)	0	10	30

Essex

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within Essex River Authority Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
59	Braintree & Bocking U.D.C.	0.8	1.3	2.0	3.5	0.9	1.6	0.3			0.4		1.9
60	Braintree R.D.C.	1.0	1.3	1.7	2.5	1.3	1.3	–	–		0.4		1.2
66	Burnham on Crouch U.D.C.	0.1	0.2	0.3	0.4	0.2	0.2	–	–		0.1		0.2
65	Chelmsford B.C.	2.4	3.8	4.8	6.8	2.0	2.9		0.9		1.9		3.9
64	Chelmsford R.D.C.	1.8	2.7	4.0	6.6	1.8	2.3		0.4		1.7		4.3
56	Colchester & District W.B.	3.7	5.6	8.5	15.0	4.3	5.6	–	–		2.9		9.4
18	Ely, Mildenhall & Newmarket W.B.	–	–	–	–	–	–	–	–	–	–	–	–
58	Halstead R.D.C.	0.5	0.8	1.1	1.6	0.7	0.8	–	–		0.3		0.8
57	Halstead U.D.C.	0.2	0.4	0.6	1.0	0.3	0.3		0.1		0.3		0.7
69	Lee Valley W. Co.	2.0	2.8	3.6	5.2	1.2	1.2		1.6		2.4		4.0
62	Maldon B.C.	0.4	0.5	0.6	0.8	0.4	0.4		0.1		0.2		0.4
63	Maldon R.D.C.	0.9	1.3	1.5	2.0	1.3	1.3	–	–		0.2		0.7
100	Metropolitan W.B.	19.0	20.0	21.0	23.0	1.0	1.0		19.0		20.0		22.0
54	Samford R.D.C.	0.6	0.9	1.3	1.7	1.0	1.0	0.1			0.3		0.7
67	Southend Wwks. Co.	13.5	20.9	27.8	45.0	13.2	13.3		7.6		14.5		31.7
68	South Essex Wwks. Co.	36.3	47.2	57.6	78.4	31.7	31.7		15.5		25.9		46.7
55	Tendring Hundred W. Co.	3.5	6.0	8.9	15.4	4.3	5.5		0.5		3.4		9.9
61	Witham U.D.C.	0.5	1.3	2.1	3.7	0.6	0.6		0.7		1.5		3.1
19	West Suffolk W.B.	2.4	3.9	6.4	9.2	2.6	2.6		1.3		3.8		6.6
	Total m.g.d.	89.6	120.9	153.8	221.8	68.6	73.6	0.4	47.7	–	80.2	–	148.2

NOTE: The statutory reservations under the South Essex Waterworks Acts and the Hanningfield Orders amounting in total to 5.1 m.g.d. have been shown as resources of the reserving authority and deducted from the resources of the supplying companies.

TABLE II. Imports

	Average Daily Transfer – m.g.		
	1971	1981	2001
(i) M.W.B. transfer from Thames area	16	–	–
(ii) Lee Valley W. Co. transfer from Great Ouse area	0.8	–	–
Total Imports m.g.d.	16.8	–	–

NOTE: If 1971 is a drought year and the statutory flow over Teddington Weir is reduced, M.W.B. demands and a bulk supply of up to 20 m.g.d. to S. Essex Wwks. Co. would be met in full and total imports would increase to 40 m.g.d. reducing the effective deficiency to 8 m.g.d.

TABLE III. Effective Deficiencies

	1971	1981	2001
Effective deficiencies, by deduction of imports from deficiencies in Table I (rounded to nearest 5 m.g.d.)	30	80	150

Lee

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within Lee Conservancy Catchment Board Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
71	Colne Valley W. Co.	1.3	1.8	2.5	4.2	1.8	1.8	–	–	0.7		2.4	
69	Lee Valley W. Co.	20.3	28.7	40.7	60.3	24.8	24.8		3.9	15.9		35.5	
70	Luton W. Co.	10.4	15.7	19.6	24.5	7.1	7.1		8.6	12.5		17.4	
100	Metropolitan W.B.	93.0	99.0	107.0	123.0	69.0	69.0		30.0	38.0		54.0	
Totals m.g.d.		125.0	145.2	169.8	212.0	102.7	102.7	–	42.5	–	67.1	–	109.3

TABLE II. Imports

	Average Daily Transfer – m.g.		
	1971	1981	2001
Lee Valley W. Co. transfer from Great Ouse area	3.9	1.3	–
Luton W. Co. transfer from Great Ouse and Thames area	8.6	12.5	14.9
Metropolitan W.B. transfer from Thames area	30.0	34.0	10.0
Total imports m.g.d.	42.5	47.8	24.9

TABLE III. Effective Deficiencies

	1971	1981	2001
Effective deficiencies, by deduction of Imports from deficiencies in Table I (rounded to nearest 5 m.g.d.)	0	20	85

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within Thames Conservancy Area and London Excluded Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiences (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
83	Banbury B.C. (i)	2.3	3.4	5.3	7.0	3.0	3.5	0.1			1.8		3.5
13	Bucks W.B.	10.7	13.5	19.5	36.7	14.6	14.6	1.1			4.9		22.1
97	Burnham, Dorney & Hitcham Wwks. Co.	1.5	1.8	3.0	5.5	1.5	1.8	–	–		1.2		3.7
73	Chesham U.D.C.	0.9	1.0	1.1	1.2	1.5	1.5	0.5		0.4		0.3	
71	Colne Valley W. Co.	31.0	36.9	43.6	55.0	28.0	28.0		8.9		16.6		27.0
84	Cotswold W.B. (ii)	2.6	3.3	4.0	5.5	6.3	6.3	3.0		2.3		0.8	
102	Croydon L.B.C. (iii)	9.6	10.3	11.5	14.0	7.2	7.2		3.1		4.3		6.8
91	East Surrey W. Co.	14.3	16.6	19.5	25.8	15.8	15.8		0.7		3.7		10.0
92	Epsom & Ewell B.C. (iv)	2.1	2.3	2.4	2.7	4.0	4.0	1.7		1.6		1.3	
90	Guildford, Godalming & District W.B. (v)	6.8	7.7	8.9	11.8	6.9	7.7	–	–		1.2		4.1
69	Lee Valley W. Co. (iii)	5.7	6.9	8.3	10.6	3.5	3.5		3.4		4.8		7.1
70	Luton W. Co.	0.6	0.7	0.9	1.2	5.4	5.4	4.7		4.5		4.2	
100	Metropolitan W.B. (vi)	234.0	243.0	255.0	279.0	213.0	289.0	46.0		34.0		10.0	
11	Mid-Northamptonshire W.B.	0.1	0.1	0.2	0.2	–	–		0.1		0.2		0.2
115	Mid-Sussex W. Co.	0.2	0.3	0.4	0.6	–	–		0.3		0.4		0.6
88	Mid-Wessex W. Co.	17.7	22.5	30.0	46.0	26.0	26.8	4.3			3.2		19.2
117	North-West Sussex W.B.	2.8	3.6	4.7	6.5	–	–		3.6		4.7		6.5
95	New Windsor B.C.	1.5	1.7	2.0	2.0	1.8	2.0	0.3		–	–	–	–
74–82	Oxford C.B.C. (including "Oxford Group" & Thame U.D.C.) (vii)	13.8	16.0	21.3	24.0	13.8	31.1	15.1		9.8		7.1	
99	Rickmansworth & Uxbridge Valley W. Co.	26.7	31.0	40.0	58.0	28.0	28.0		3.0		12.0		30.0
98	Slough B.C.	5.0	6.5	7.5	10.0	5.0	6.0		2.0		3.0		5.5
123	Southampton C.B.C.	0.7	1.1	1.8	2.5	1.2	*1.2	0.1			0.6		1.3
94	South-West Suburban W. Co. (iii) & (viii)	11.6	12.8	15.3	20.3	10.0	7.0		5.8		8.3		13.3
101	Sutton Olstrict W. Co.	11.5	12.8	14.8	18.8	14.5	16.5	3.7		1.7			2.3
86	Swindon B.C.	7.6	9.9	14.2	21.7	9.2	10.1	0.2			4.1		11.6
87	Thames Valley W.B. (ix)	21.2	29.0	48.1	84.1	31.0	31.0	2.0			17.1		53.1
72	Watford B.C.	3.4	3.6	4.2	5.7	5.4	5.4	1.9		1.2			0.3
89	Wey Valley W. Co.	3.8	4.8	6.5	11.8	4.7	7.3	2.5		0.8			4.5
85	Witney U.D.C. (x)	0.4	0.7	1.3	2.6	0.7	0.7	–	–		0.6		1.8
93	Woking & Olstrict W. Co.	10.7	15.5	19.5	27.5	16.2	18.2	2.7			1.3		9.3
	Totals (rounded to nearest 5 m.g.d.)	460.0	520.0	615.0	800.0	480.0	580.0	90.0	30.0	55.0	90.0	25.0	245.0

NOTES (i) *Banbury B.C. Demand figures shown include for S.E. Study proposals.*

(ii) *Cotswold W.B. Figures for demand exclude bulk supply to Severn area:- 1964 0.4 m.g.d., 1971 and thereafter 0.7 m.g.d.*

(iii) *Croydon L.B.C., Lee Valley W. Co., and S.W. Suburban W. Co. Resources exclude bulk supplies from M.W.B.*

(iv) *Epsom and Ewell B.C. Bulk supply is also afforded, based on supply of surplus water, 0.6 m.g.d. Agreement expires in 1971.*

(v) *Guildford, Godalming and District W.B. Demand excludes transfers to Sussex areas:- 1964 0.4 m.g.d.; 1971 0.5 m.g.d; 1981 0.6 m.g.d; 2001 0.7 m.g.d.*

(vi) *Metropolitan W.B. Demand excludes bulk supplies to other water undertakings. Authorised resources include both Wraysbury and Datchet reservoirs and ignore Thames Abstraction Orders which expire in 1967. If 1971 should be a drought year the Board could only meet in full its own demands in Essex (i.e. a further 3 m.g.d.) and also its bulk supply commitment of 20 m.g.d. to South Essex Wwks. Co. by a reduction of the statutory flow over Teddington Weir.*

(vii) *Oxford C.B.C. Authorised resources include whole of Farmoor reservoir (17 m.g.d.); yield of Stage 1 (now constructed) 6.5 m.g.d., Stage 11 10.5 m.g.d. 'Oxford Group' comprises Abingdon B.C (76), Bicester U.D.C.(79), Chipping Norton B.C.(82), Chipping Norton R.D.C.(81), Faringdon R.D.C.(77), Ploughley R.D.C.(80), Thame U.D.C.(74) and Witney R.D.C.(78).*

(viii) *South-West Suburban W.Co. 1964 resources greater than authorised resources because of temporary powers of abstraction.*

(ix) *Thames Valley W.B. Authorised resources exclude estimated yield of 11 m.g.d. from boreholes for which authorisation has only been given to date for drilling and test pumping.*

(x) *Witney U.D.C. Resources - 0.7 available for U.D.C. Average abstraction right = 1.5 (0.8 commitment to R.D.C.). 2001 demand estimated by W.R.B.*

The Effect of Imports and Re-Use

TABLE II. Imports

	Average Daily Import – m.g.		
	1971	1981	2001
A Imports producing effluents discharged below Teddington Weir Metropolitan W.B. Import (to L.E.A.) from Kent area, say	10.0	5.0	–
B Imports producing effluents discharged above Teddington Weir			
(i) East Surrey W. Co. import from Kent area	0.7	3.7	3.0
(ii) North-West Sussex W.B. Import from Kent and Sussex areas	3.6	4.7	3.6
(iii) Mid-Sussex W. Co. Import from Kent area (bulk supply from North-West Sussex W.B.)	0.3	0.4	0.6
(iv) Mid-Northents W.B. Import from Great Ouse area	0.1	0.2	0.2
Totals (rounded to 5 m.g.)	5.0	10.0	10.0

TABLE IIIA. Demands, resources, surpluses and deficiencies of undertakings giving rise to effluents discharged below Teddington Weir

Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Net Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
	1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
							+	–	+	–	+	–
Colne Valley W. Co. (i)	21.7	22.1	26.2	33.0	19.6	19.6		2.5		6.6		13.4
Croydon L.B.C.	9.6	10.3	11.5	14.0	7.2	7.2		3.1		4.3		6.8
Lee Valley W. Co.	5.7	6.9	8.3	10.6	3.5	3.5		3.4		4.8		7.1
Metropolitan W.B.	234.0	243.0	255.0	279.0	213.0	289.0	46.0		34.0		10.0	
Rickmansworth & Uxbridge Valley W.Co.(ii)	13.4	15.5	20.0	29.0	14.0	14.0		1.5		6.0		15.0
S.W. Suburban W. Co. (ii)	5.8	6.4	7.6	10.1	5.0	3.5		2.9		4.1		6.6
Sutton District W. Co.	11.5	12.8	14.8	18.8	14.5	16.5	3.7		1.7			2.3
Totals (rounded to 5 m.g.)	300.0	315.0	345.0	395.0	275.0	355.0	50.0	15.0	35.0	25.0	10.0	50.0
EFFECTIVE DEFICIENCIES (by addition of imports)							–	5	–	20	–	50

NOTES: *(i) Colne Valley W. Co. discharge about 70 per cent of their consumption below Teddington Weir at present but this percentage is likely to fall to 60 per cent with future development. The above figures are either 60 per cent or 70 per cent of the figures in Table I as appropriate.*

(ii) Denotes an undertaking which discharges about one-half of its consumption below Teddington Weir and the above figures are 50 per cent of those in Table I.

TABLE IIIB. Total demands, resources, surpluses and deficiencies of undertakings giving rise to effluent discharged above Teddington Weir

	Average Daily Demand – m.g.				Resources – m.g.d.		Net Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
	1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
							+	–	+	–	+	–
1 Total demands etc. for whole area, from Table I	460.0	520.0	615.0	800.0	480.0	580.0	90.0	30.0	55.0	90.0	25.0	245.0
2 Total demands etc. giving rise to effluents discharged below Teddington Weir, from Table IIIA	300.0	315.0	345.0	395.0	275.0	355.0	50.0	15.0	35.0	25.0	10.0	50.0
3 Total demands etc. giving rise to effluents discharged above Teddington Weir, by difference	160.0	205.0	270.0	405.0	205.0	225.0	40.0	15.0	20.0	65.0	15.0	195.0
4 EFFECTIVE DEFICIENCIES (by addition of imports)							–	10	–	55	–	185

NOTE: *If the 'upstream' effective deficiencies are made good in full, water would be made available for export equal in quantity to the difference of the 'upstream' and 'downstream' effective deficiencies i.e. 5 m.g.d. in 1971, 35 m.g.d. in 1981 and 135 m.g.d. in 2001. The total effective deficiencies given in Table IIIB exceed the total quantities required from new conservation works by these amounts.*

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within Kent River Authority Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
108	Canterbury & District W. Co.	4.2	5.7	7.7	11.5	7.0	7.0	1.3			0.7		4.5
110	Deal B.C. (iii)	1.0	1.2	1.5	2.1	1.4	1.4	0.2			0.1		0.7
111	Dover B.C.	1.4	1.5	1.6	2.0	1.6	1.6	0.1					0.4
114	Eastbourne W. Co.	0.8	1.2	1.7	2.5	1.2	1.5	0.3			0.2		1.0
91	East Surrey W. Co.	2.1	2.5	2.9	4.0	2.2	7.2	4.7		4.3		3.2	
112	Folkestone & District W. Co.	3.8	5.7	7.7	10.6	4.3	6.5	0.8			1.2		4.1
113	Hastings C.B.C.	0.6	0.9	1.3	2.2	5.0	5.0	4.1		3.7		2.8	
106	Maidstone W. Co.	3.0	4.0	5.0	8.2	5.1	5.9	1.9		0.9			2.3
107	Medway W.B. (i)	19.7	27.6	38.6	67.1	23.0	25.0		2.6		13.6		42.1
100	Metropolitan W.B.	24.0	26.0	29.0	33.0	36.0	36.0	10.0		7.0		3.0	
105	Mid-Kent W. Co. (iii)	11.8	16.5	23.0	36.0	12.5	20.5	4.0			2.5		15.5
115	Mid-Sussex W. Co.	2.0	2.7	3.8	7.0	2.1	2.5		0.2		1.3		4.5
117	North-West Sussex W.B. (ii)	–	–	–	–	3.1	3.1	3.1		3.1		3.1	
103	Sevenoaks & Tonbridge W. Co.	2.6	3.4	4.5	6.0	4.5	4.5	1.1		–	–		1.5
109	Thanet W.B. (iii)	6.6	7.7	9.1	11.8	7.2	8.7	1.0			0.4		3.1
104	Tunbridge Wells B.C.	2.6	3.2	3.9	4.8	1.8	1.8		1.4		2.1		3.0
	Totals m.g.d.	86.2	109.8	141.3	208.8	118.0	138.2	32.6	4.2	19.0	22.1	12.1	82.7

NOTES: *(i) Medway W.B. figures include Sheppey W.B. and Sittingbourne and Milton U.D.C. which were amalgamated with Medway W.B. on 1st April, 1965.*

(ii) North-West Sussex W.B. apparent surplus is used to supply Crawley (1.9) and to afford a bulk supply (1.2 m.g.d.) to Mid-Sussex W. Co. which is consumed in Kent, Sussex and Thames areas.

(iii) This Table does not take account of the transfer to the Thanet Water Board of the undertaking of Deal B.C. and part of the undertaking of Mid-Kent W. Co. (1st April 1966).

TABLE II. Imports - Nil

TABLE III. Effective Deficiencies

	1971	1981	2001
Effective deficiencies, i.e. deficiencies in Table 1 (rounded to nearest 5 m.g.d.)	5	20	85

Sussex

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within Sussex River Authority Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
116	Brighton C.B.C. (i)	15.4	17.4	20.4	23.9	16.0	16.0		1.4		4.4		7.9
114	Eastbourne W. Co.	7.0	9.2	11.9	17.2	8.2	8.2		1.0		3.7		9.0
91	East Surrey W. Co.	0.1	0.1	0.2	0.2	–	–		0.1		0.2		0.2
90	Guildford, Godalming & District W.B.	0.4	0.5	0.6	0.7	–	–		0.5		0.6		0.7
113	Hastings C.B.C.	2.9	3.6	5.2	7.8	1.1	1.1		2.5		4.1		6.7
115	Mid-Sussex W. Co.	5.6	7.0	9.4	15.0	5.0	8.6	1.6			0.8		6.4
117	North-West Sussex W.B.	4.5	5.7	6.9	9.1	9.6	10.2	4.5		3.3		1.1	
119	Portsmouth W. Co.	6.5	8.1	10.0	15.7	7.7	11.0	2.9		1.0			4.7
89	Wey Valley W. Co.	0.6	0.7	1.0	1.9	0.9	2.1	1.4		1.1		0.2	
118	Worthing B.C. (i),(ii)	7.1	8.5	10.4	13.5	9.0	9.0	0.5			1.4		4.5
	Total m.g.d.	50.1	60.8	76.0	105.0	57.5	66.2	10.9	5.5	5.4	15.2	1.3	40.1

NOTES: *(i) Brighton and Worthing operate their pumps in co-operation - joint capacity 25 m.g.d.*
(ii) Worthing B.C. demand figures include allowance for Arundel B.C.

TABLE II. Imports

	Average Daily Transfer – m.g.		
	1971	1981	2001
East Surrey W. Co. from Kent Area	0.1	0.2	0.2
Guildford, Godalming & District W.B. from Thames Area	0.5	0.6	0.7
Hastings C.B.C. from Kent Area	2.5	3.7	2.8
North-West Sussex W.B. from Kent Area (bulk supply to Mid-Sussex W. Co.) (iii)	–	0.2	–
Total imports m.g.d.	3.1	4.7	3.7

NOTE: *(iii) No apparent deficiency to be met in 1971 but 0.4 m.g.d. available for import.*

TABLE III. Effective Deficiencies

	1971	1981	2001
Effective deficiencies by deduction of imports from deficiencies in Table 1 (rounded to nearest 5 m.g.d.)	5	10	35

Hampshire

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within Hampshire River Authority Area

Ref. on Map 2	Water Undertakings		Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
			1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
									+	–	+	–	+	–
120	Lymington B.C.	(i)	0.4	0.5	0.6	1.0	0.4	0.4		0.1		0.2		0.6
88	Mid-Wessex W. Co.	(ii)	0.3	0.4	1.0	1.5	1.0	1.0	0.6					0.5
119	Portsmouth W. Co.		27.7	35.6	46.8	79.2	22.3	23.9		11.7		22.9		55.3
123	Southampton C.B.C.	(iii)	24.4	38.5	56.8	91.9	26.0	36.4		2.1		20.4		55.5
133	West Hampshire W. Co.		9.3	12.2	12.7	13.6	–	–		12.2		12.7		13.6
89	Wey Valley W. Co.		0.2	0.2	0.3	0.5	0.2	0.2	–	–		0.1		0.3
122	Winchester B.C.		2.2	2.9	3.9	6.7	3.2	3.2	0.3			0.7		3.5
Total m.g.d.			64.5	90.3	122.1	194.4	53.1	65.1	0.9	26.1	–	57.0	–	129.3

NOTES: *(i) Lymington B.C. - Future demands estimated by Water Resources Board.*
(ii) Mid-Wessex W. Co. - 1964 demand estimated by Water Resources Board.
(iii) Southampton C.B.C. figures include Winchester R.D.C.

TABLE II. Imports

	Average Daily Transfer – m.g.		
	1971	1981	2001
West Hampshire W. Co. from Avon & Dorset area	12.2	12.7	13.6
Portsmouth W. Co. from Sussex area	2.9	1.0	–
Total Imports m.g.d.	15.1	13.7	13.6

TABLE III. Effective Deficiencies

	1971	1981	2001
Effective deficiencies by deduction of Imports from deficiencies in Table I (rounded to nearest 5 m.g.d.)	10	45	115

Avon and Dorset

TABLE I. Demands, resources, surpluses and deficiencies of statutory water undertakings within Avon and Dorset River Authority Area

Ref. on Map 2	Water Undertaking	Average Daily Demand – m.g.				Resources – m.g.d.		Apparent Overall Deficiencies (–) or Surpluses (+) on Authorised Resources – m.g.d.					
		1964	1971	1981	2001	1964	Authorised	1971		1981		2001	
								+	–	+	–	+	–
134	Bournemouth & District W. Co.	10.1	12.0	15.5	25.5	17.0	17.0	5.0		1.5			8.5
126	North Wilts W.B.	0.1	0.1	0.2	0.2	0.6	0.6	0.5		0.4		0.4	
–	Proposed Dorset W.B. (i)	14.4	20.7	27.9	46.1	19.1	21.2	0.5			6.7		24.9
133	West Hampshire W. Co.	3.3	4.4	5.6	8.4	24.0	24.0	19.6		18.4		15.6	
131	West Wilts W.B.	2.7	3.3	3.9	5.6	3.1	4.2	0.9		0.3			1.4
–	Proposed South Wilts W.B. (ii)	4.5	5.1	5.9	7.6	7.1	7.1	2.0		1.2			0.5
132	Wessex W.B.	0.6	0.7	0.9	1.4	0.6	0.6		0.1		0.3		0.8
141	East Devon W.B.	0.2	0.3	0.4	0.5	0.3	0.3	–	–		0.1		0.2
	Total m.g.d.	35.9	46.6	60.3	95.3	71.8	75.0	28.5	0.1	21.8	7.1	16.0	36.3

NOTES: *(i) The proposed Dorset W.B. includes the following Undertakings:- Poole and East Dorset W.B. (135), West Dorset W.B.(140), Dorchester R.D.C.(136), Dorchester B.C.(137), Portland U.D.C. (139) and the Weymouth W. Co.(138).*

(ii) The proposed South Wilts W.B. includes the following Undertakings:- Amesbury R.D.C.(127), Pewsey R.D C.(125), Salisbury B.C.(128), Salisbury and Wilton R.D.C.(130), Wilton B.C.(129), and the Cholderton and District W. Co.(124).

TABLE II. Imports - Nil

TABLE III. Effective Deficiencies

	1971	1981	2001
Effective deficiencies from Table I (rounded to nearest 5 m.g.d.)	0	5	35

APPENDIX II

Appendix II

WATER CONSUMPTION IN SOUTH EAST ENGLAND

Introduction

The preliminary statement in this Study dated July, 1965 was submitted to the two Technical Committees of the Working Party for South East England and resulted in a request that the curve of total consumption per capita which was shown on Diagram 1 attached to that statement should be supplemented by two additional curves indicating the metered and unmetered consumptions separately. It was suggested that this would enable an individual assessment to be made of the trend in future demand for each type of supply.

The Committees expressed the view, however, that the curve of metered consumption should be plotted on the basis of the total quantity of water supplied daily through the meters and should not be related to population.

It had been explained in the preliminary statement that separate records of metered and unmetered supplies were not available for any earlier period than 1957 and in the case of many undertakings than 1959 and it had been decided for this reason that curves based upon so short a period of years would be unreliable.

The conclusions arrived at in the earlier statement were based upon examination of the records and statistics of 52 water undertakings selected from the 155 throughout the South East England Study Area. The method of selection of the 52 undertakings in the four distinct zones involved consideration of the extent of each statutory supply area, the population, the concentration of industry and the type and density of residential development. Every effort was made to select undertakings which could be considered typical of the particular zone in which they were situated. In this way it was believed that the undertakings selected would give a fair representation of conditions in the whole of South East England and that the resulting conclusions would be applicable throughout the Study Area.

The 52 undertakings whose records and statistics were analysed to form the basis of the preliminary statement were:-

(i) London Conurbation. Comprising 3 undertakers

Colne Valley Water Company
Croydon Corporation
Sutton District Water Company

(ii) Inner Country Ring. Comprising 7 undertakers

Lee Valley Water Company
South Essex Waterworks Company
Rickmansworth and Uxbridge Valley Water Company
Medway Water Board
Sevenoaks-Tonbridge Water Company
East Surrey Water Company
Woking and District Water Company

(iii) Outer Country Ring. Comprising 12 undertakers

Luton Water Company
Thames Valley Water Board
Bucks Water Board
Southend Waterworks Company
Chelmsford Corporation
Chelmsford Rural District Council
Mid-Wessex Water Company
Mid-Kent Water Company
Wey Valley Water Company
Guildford Godalming and District Water Board
Mid-Sussex Water Company
North-West Sussex Water Company

(iv) Remainder of Area. Comprising 30 undertakers

Mid-Beds Water Board	Southampton Corporation
Oxford Corporation	West Hampshire Water Company
Mid-Northants Water Board	Isle of Wight Water Board
Tendring Hundred Waterworks Company	Swindon Corporation
Colchester & District Water Board	Poole & East Dorset Water Board
East Anglian Water Company	Cambridge Water Company
Dehen Rural District Council	Ely, Mildenhall & Newmarket Water Board
West Suffolk Water Board	Nene & Ouse Water Board
Folkestone & District Water Company	Peterborough Corporation
Thanet Water Board	Wayland Rural District Council
Canterbury & District Water Company	Mitford & Launditch Rural District Council
Eastbourne Waterworks Company	Norwich Corporation
Brighton Corporation	Cromer Urban District Council
Portsmouth Water Company	Erpingham Rural District Council
Blofield & Flegg Rural District Council	Docking Rural District Council

As the result of the subsequent request from the Technical Committees the following 6 undertakings were selected from the original 52 and asked to provide details of their metered and unmetered supplies for each of the years 1946 and 1964 together with the populations supplied. Again these undertakings were selected because they appeared to be typical of their particular zone on the basis of the several factors enumerated earlier.

Colne Valley Water Company	London Conurbation	Diagram 2
South Essex Waterworks Company	Inner Country Ring	" 3
East Surrey Water Company	Inner Country Ring	" 4
Bucks Water Board	Outer Country Ring	" 5
Oxford Corporation	Remainder of Area	" 6
Southampton Corporation	Remainder of Area	" 7

Graphs have been drawn for each of these undertakings and are shown in the Diagrams numbered 2 to 7 attached to this statement.

The graphs in each case show seven individual curves for metered, unmetered and total supplies expressed in m.g.d. and in g.p.h.p.d. together with the population in the statutory supply area.

The graph on Diagram 1 which is described in more detail under the sub-heading 'The Graphs' below, includes a summation curve of the total metered supplies given by these 6 undertakings.

The Undertakings

Four of the six selected water undertakings for which additional graphs have been produced have been subject to varying degrees of re-grouping since the war.

In the case of the Colne Valley Water Company the most substantial addition was in 1958/59 when the population increased by some 74,000. In the two following years 18,000 and 8,000 were added respectively.

The population supplied by the East Surrey Water Company expanded by 8,000 in 1958/59.

In 1949/50 the population in the Bucks Water Board area increased by 10,000 but in 1959/60 an increase of 164,000 more than doubled the total population as the result of re-grouping.

Re-grouping also took place with the Southampton Corporation undertaking in 1958 and more extensively in 1962 but these additional populations have not been included in the statistics.

The incidence of all these re-groupings is recorded on the graphs and they are referred to by numbers in the following list.

DIAGRAM NO.	STATUTORY UNDERTAKING	CONSTITUENT UNDERTAKING	DATE OF ORDER	NO. ON GRAPH
2	Colne Valley Water Co.	St. Albans W. Co.	1.7.59	1
		Harpenden W. Co. Ltd.	30.9.60	2
		St. Albans R.D.C.	1.4.62	3
4	East Surrey Water Co.	Dorking Water Co.	1.1.59	1
5	Bucks Water Board	Chiltern Hill Springs W. Co.	1946	-
		Rural Districts W. Co.	1950	1
		Wing R.D.C.	1.4.50	
		Brackley B.C.	1.4.60	
		Marlow W. Bd.	1.4.60	
		High Wycombe B.C.	1.4.60	
		Bletchley U.D.C.	1.4.60	
		Newport Pagnell U.D.C.	1.4.60	2
		Wolverton U.D.C.	1.4.60	
		Brackley R.D.C.	1.4.60	
		Newport Pagnell R.D.C.	1.4.60	
		Towcester R.D.C.	1.4.60	
		Wycombe R.D.C.	1.4.60	
7	Southampton C.B.C.	Hursley Park Estate	9.7.58	1
		New Forest R.D.C.	1.4.62	
		Kingsclere & Whitchurch R.D.C.	1.4.62	
		Andover B.C.	1.4.62	2
		Andover R.D.C.	1.4.62	
		Romsey & Stockbridge R.D.C.	1.4.62	

The Graphs

It will be seen from the various curves that the influence of re-grouping is most marked in the case of the Bucks Water Board. It is of interest to note on this particular graph (Diagram 5) that the curve of unmetered consumption per capita shows an upward trend coincident with the increase of population following the major re-grouping, but over the same period the curve of metered consumption when related to this substantially increased population shows a pronounced drop.

That this is an entirely false conception can be seen by reference to the curve of total metered consumption which records a considerable increase at this period of regrouping.

This would appear also to support the contention that in areas subject to substantial annual variation of population, or such as that of the Thanet Water Board to seasonal variation the consumption per capita of water supplied by meter is not a reliable indication of likely future demand. In fact the actual total of metered consumption can increase whilst the population falls. The curves in the case of Bucks Water Board show that the reverse is equally true, although the two influences are not necessarily similar.

On the graph in Diagram 1 curves have been drawn of the total metered consumption expressed in m.g.d. and representing a summation of the metered supplies given by the six selected undertakings. In addition curves are shown

for the per capita consumption via metered and unmetered supplies, but in these cases the figures have been adjusted by means of a factor calculated by reference to the curve of total consumption of the fifty-two undertakings drawn on Diagram 1 of the preliminary paper. In this way it has enabled a comparison to be made between the earlier curve and those now presented.

The following statistics show the basis of the adjustment in the curves over the period of 19 years.

Year	Total Consumption – g.p.h.p.d.		Adjustment Factor	Averaged Consumption g.p.h.p.d. 6 Authorities		Adjusted Figures	
	52 Authorities	6 Authorities		Unmetered	Metered	Unmetered	Metered
						g.p.h.p.d.	g.p.h.p.d.
1946	36.5	42.5	.86	29.2	13.2	25.5	11.6
47	37.2	42.7	.87	29.3	13.4	25.5	11.7
48	37.8	42.2	.90	28.5	13.6	25.6	12.2
49	37.8	42.3	.90	28.4	13.9	25.5	12.5
1950	37.3	42.4	.88	27.8	14.6	24.5	12.8
51	37.7	42.7	.88	27.5	15.2	24.2	13.4
52	37.8	43.0	.88	27.5	15.4	24.2	13.5
53	38.6	43.7	.89	27.5	16.2	24.4	14.4
54	39.9	43.8	.91	26.8	17.0	24.4	15.5
55	40.5	45.0	.90	26.9	18.1	24.2	16.3
56	40.9	45.9	.89	27.6	18.3	24.6	16.3
57	42.4	46.7	.91	28.6	18.1	26.0	16.5
58	41.6	46.9	.89	28.4	18.6	25.2	16.6
59	44.9	48.8	.92	29.5	19.3	27.1	17.8
1960	45.8	48.9	.94	29.7	19.2	28.0	18.1
61	47.3	50.5	.94	31.1	19.5	29.2	18.3
62	47.8	51.5	.93	31.4	20.1	29.2	18.9
63	48.5	51.8	.94	31.6	20.2	29.7	19.0
64	48.8	52.4	.93	32.2	20.3	30.0	18.9

The curve of unmetered consumption per capita on Diagram 1 shows that in the immediate post-war years demand remained almost constant even dropping a little, and this condition continued until about 1956. Then a gradual increase became apparent the rate of which rose steadily until 1961 after which it almost levelled off again just reaching 30 g.p.h.p.d. (adjusted figure - actual average of the 6 undertakings - 32.2 g.p.h.p.d.). The rate of increase appears to have been highest between 1956 and 1961.

On the other hand the curve of metered consumption per capita indicates that there was a sustained increase between 1946 and 1962 except for the period 1955 to 1958 when demand remained almost constant at 16.5 g.p.h.p.d. (adjusted) 18.3 g.p.h.p.d. (actual).

The rate of increase between 1946 and 1962 appears to have been fairly steady except during the period 1952 to 1955 when it almost doubled (an increase of 3 g.p.h.p.d. in three years compared with about 3 g.p.h.p.d. in five years). It will be seen that this period of enhanced rate of increase coincided in part with the period of constant demand for unmetered supplies which is referred to above and which is clearly defined on the curve.

The curve of total metered consumption indicates a fairly even rate of increase from 1946 to 1960 except between the years 1955 and 1957 when the consumption remained almost constant as in the case of the per capita curve, indicating a fall in the annual rate of increase.

Conclusions

As noted the adjusted curve of metered consumption per capita shows a fairly even rate of increaee from 1946 until 1955 when it flattene off completely. From 1958 to 1962 consumption increased hut the curve indicates that it again became virtually constant from 1962 onwards.

As far as a forecast of future trends is concerned there appear to he two possihilitiee, the first a curve projected to the year 2,000 usıng the lsst three years as an indication that the consumption of metered supplies has reached a peak and will henceforward remain virtually constant at the figure indicated for 1964. If this broad assumption cen he accepted then the projection may he regarded ae the lower limit of the trend zone.

In order to project an upper limit it is necessary to have regard to the earlier years during which annual consumption was etill increasing although at a progressively lower rate.

The curve in Diagram 1 illustrates these differing rates of increase and they appear to fall into two aections, one prior to 1955 and the other hetween 1958 and 1962. If an average is taken of each of these two dietinct rates of increase and a simple progreesion of them is used ae a hasis, a etraight line projection to the year 2,000 tangential to the curve at the year 1962 can be taken ae the top limit of the trend zone and this is illustrated in Diagram 1.

In the case of the adjusted curve of unmetered consumption per capita the pattern of past demand hes heen quite different as has heen noted. However, the upper and lower limits of a trend zone have heen assessed in a similar manner and are shown in Diagram 1. For the lower limit the average rate of increase per capita for the four years 1961 to 1964 has heen used, and for the upper limit the average has heen taken over the years 1953 to 1964.

The two trend zones thus ohtained have heen added together and the resulting composite zone superimposed for comparison purposes on the original trend zone in the preliminary paper.

The new projection euggests thst slightly lower limits then were forecast ae the result of the earlier exercise may he appropriate.

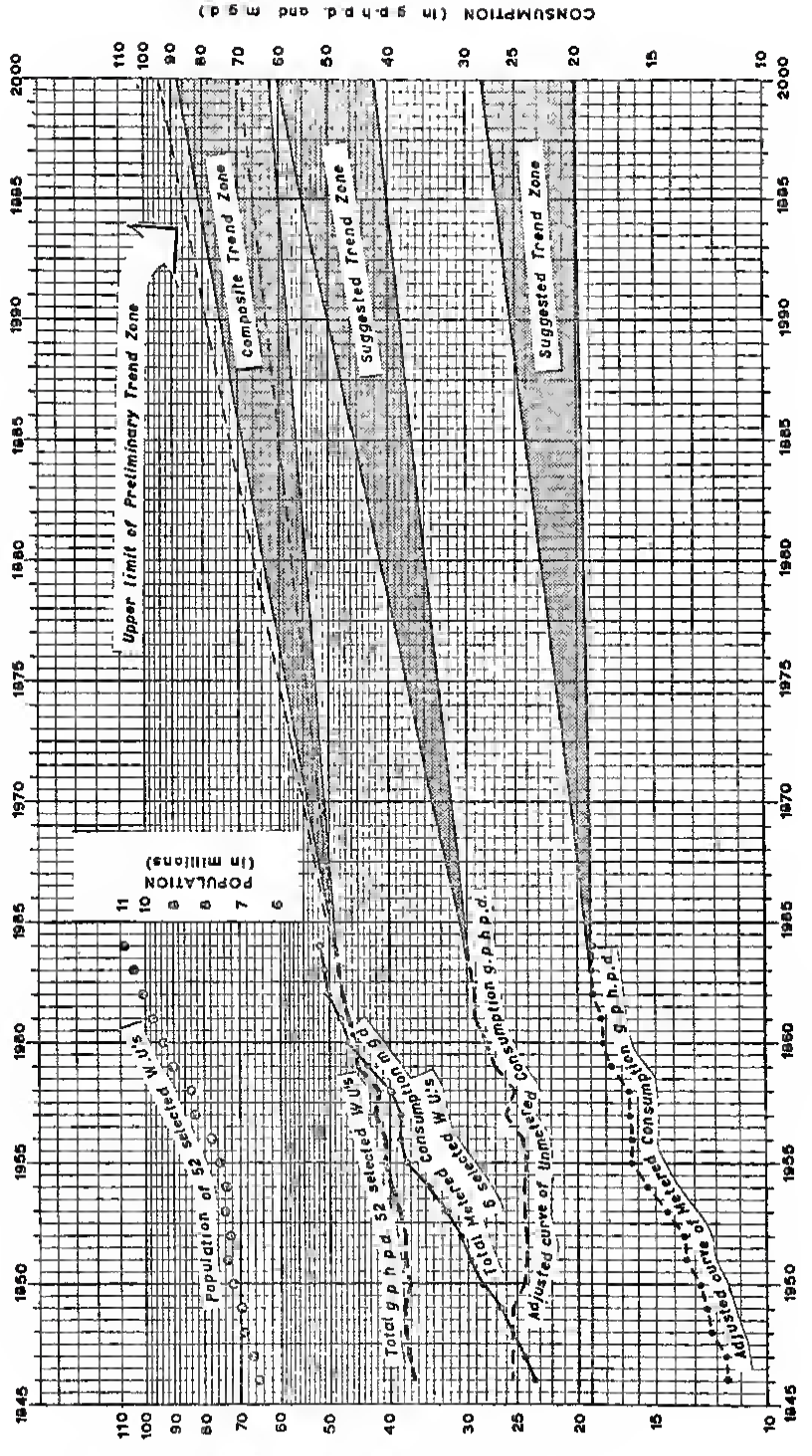
The new suggeeted limits for the year 2,000 are 62 g.p.h.p.d. and 88 g.p.h.p.d. as compared with the earlier figures of 70 g.p.h.p.d. and 94.5 g.p.h.p.d.

For the year 1981 the limits indicated hy the trend zone are 55 g.p.h.p.d. and 64 g.p.h.p.d.

Diagram 1

WATER CONSUMPTION IN SOUTH EAST ENGLAND

CURVES OF POPULATION & CONSUMPTION



Appendix II

Diagram 2

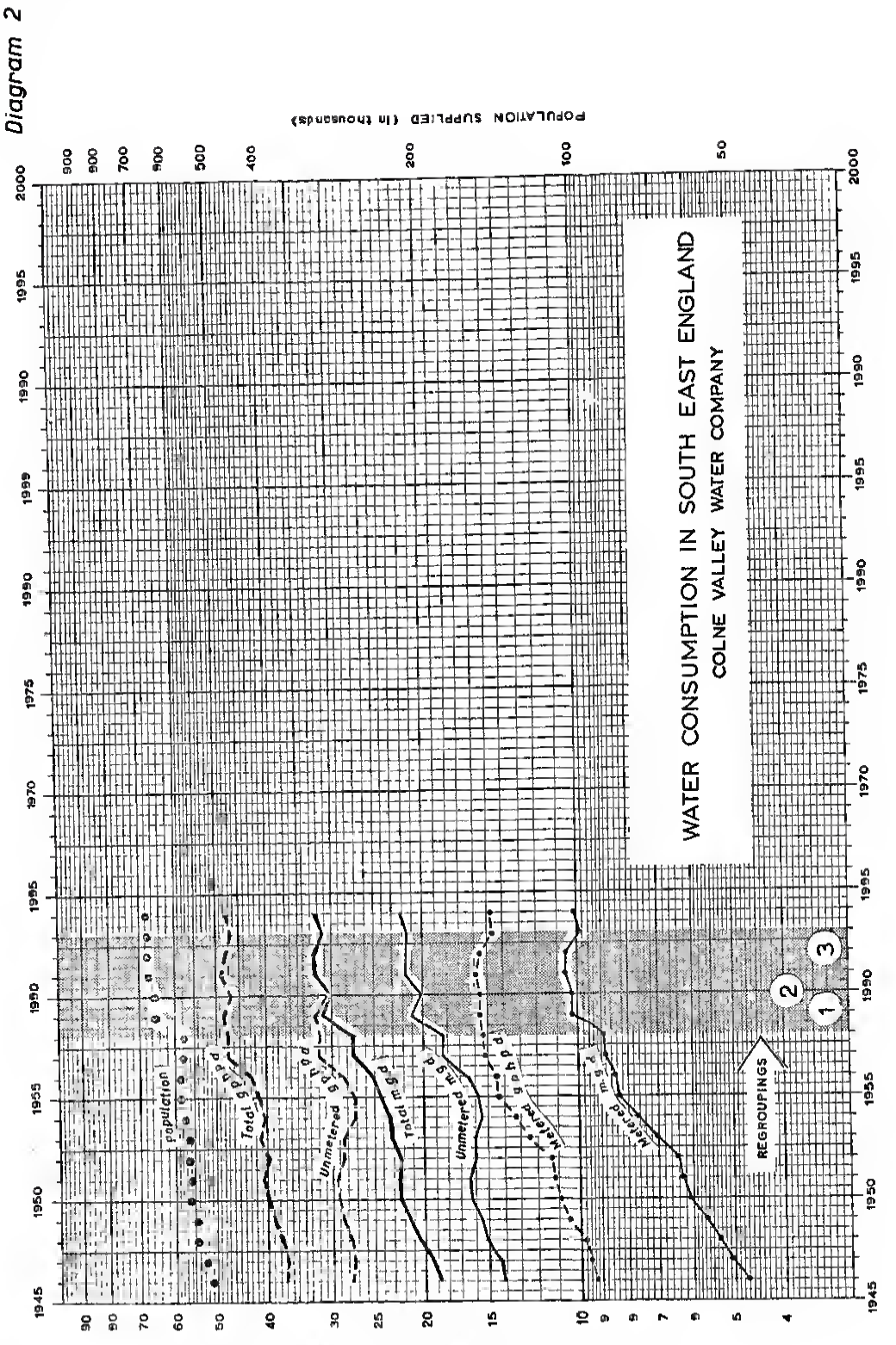


Diagram 3

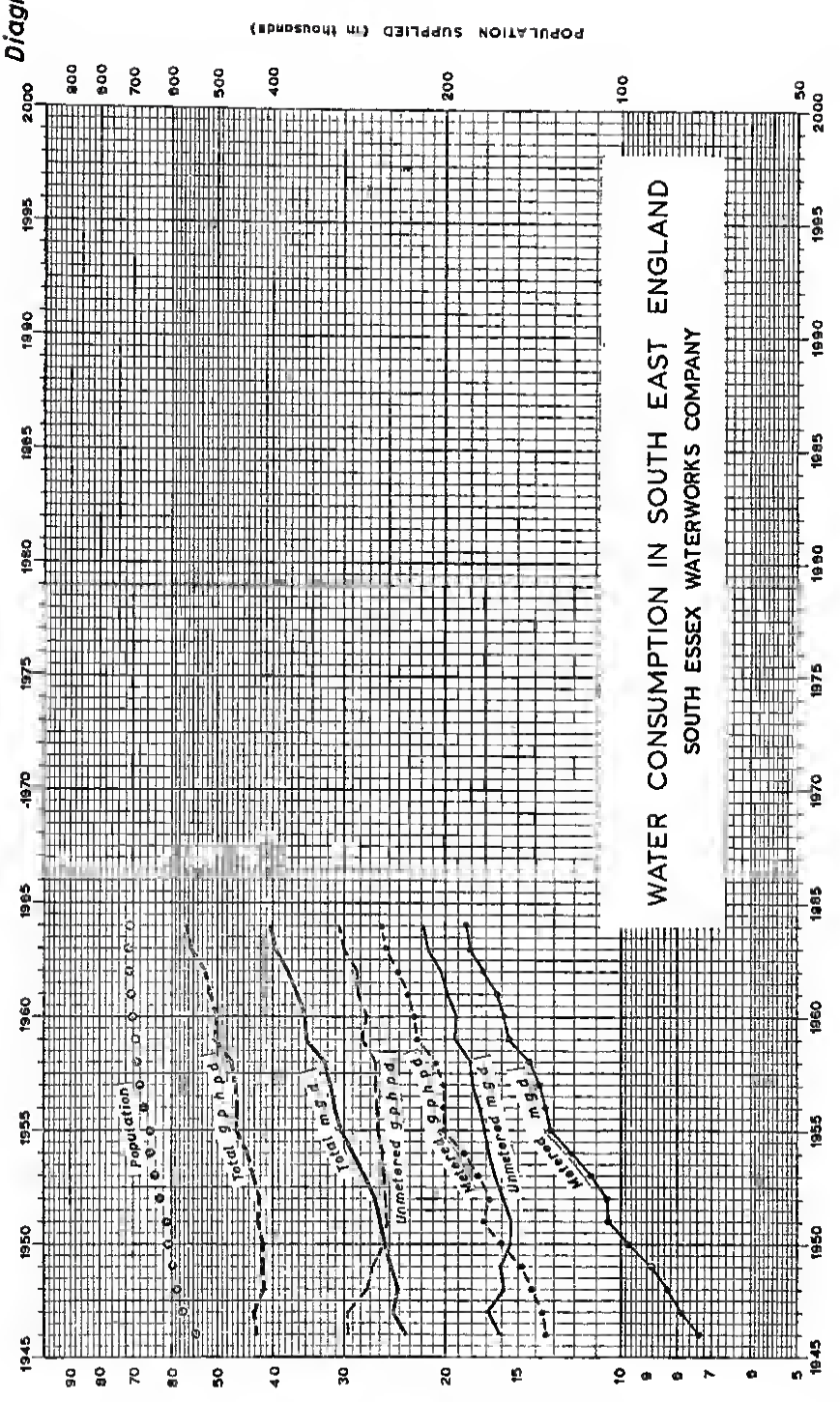


Diagram 2

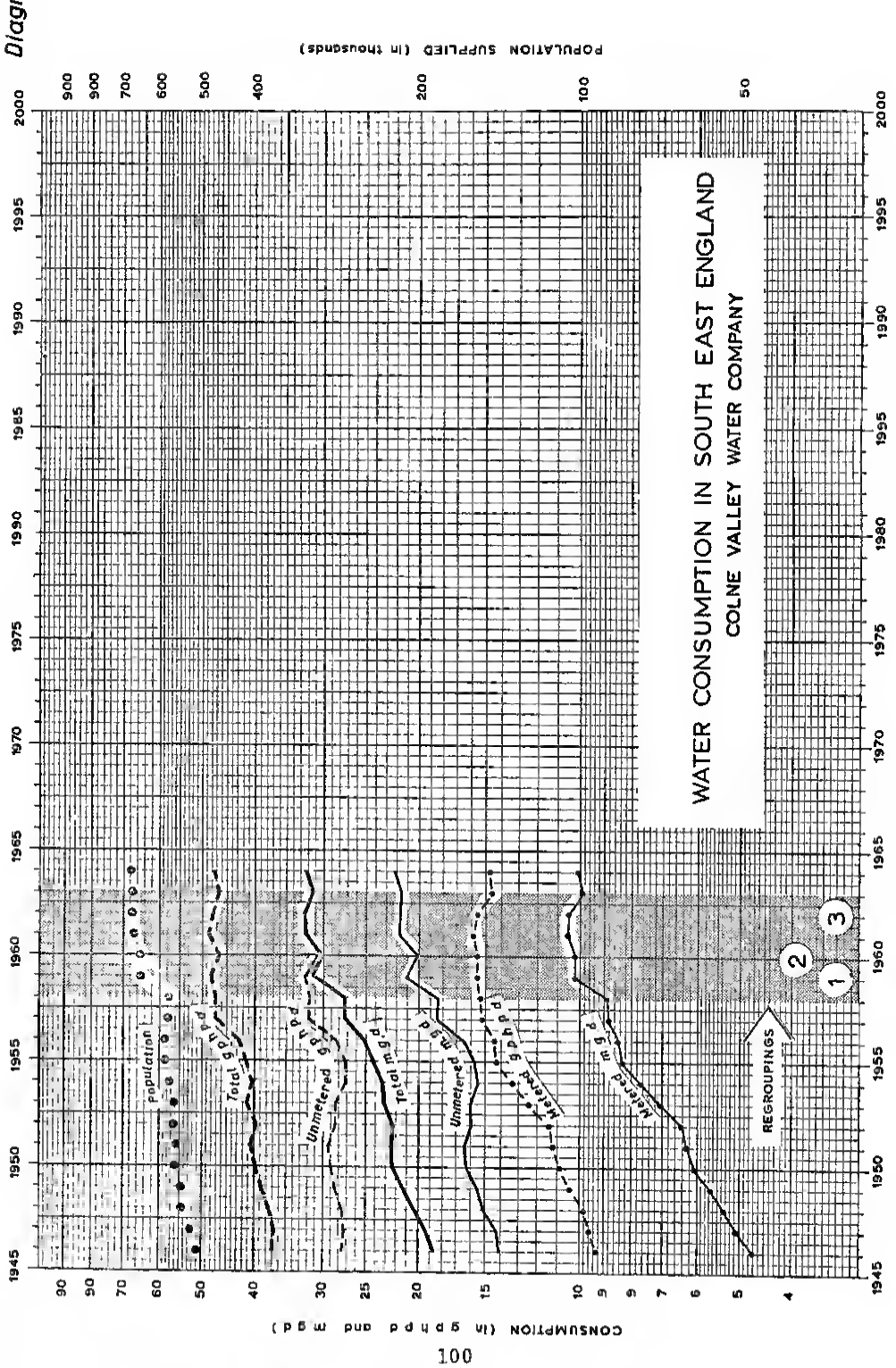


Diagram 3

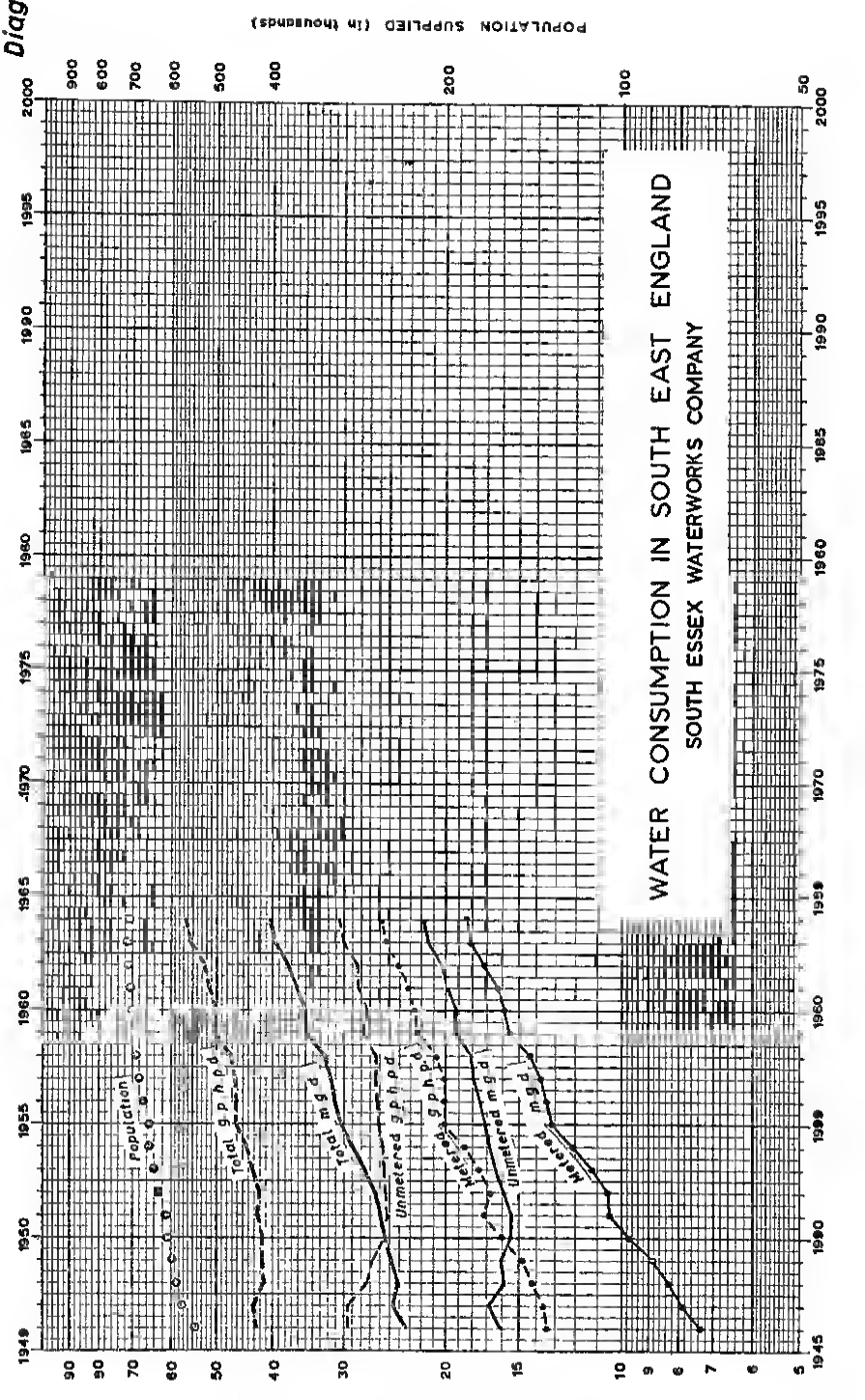


Diagram 6

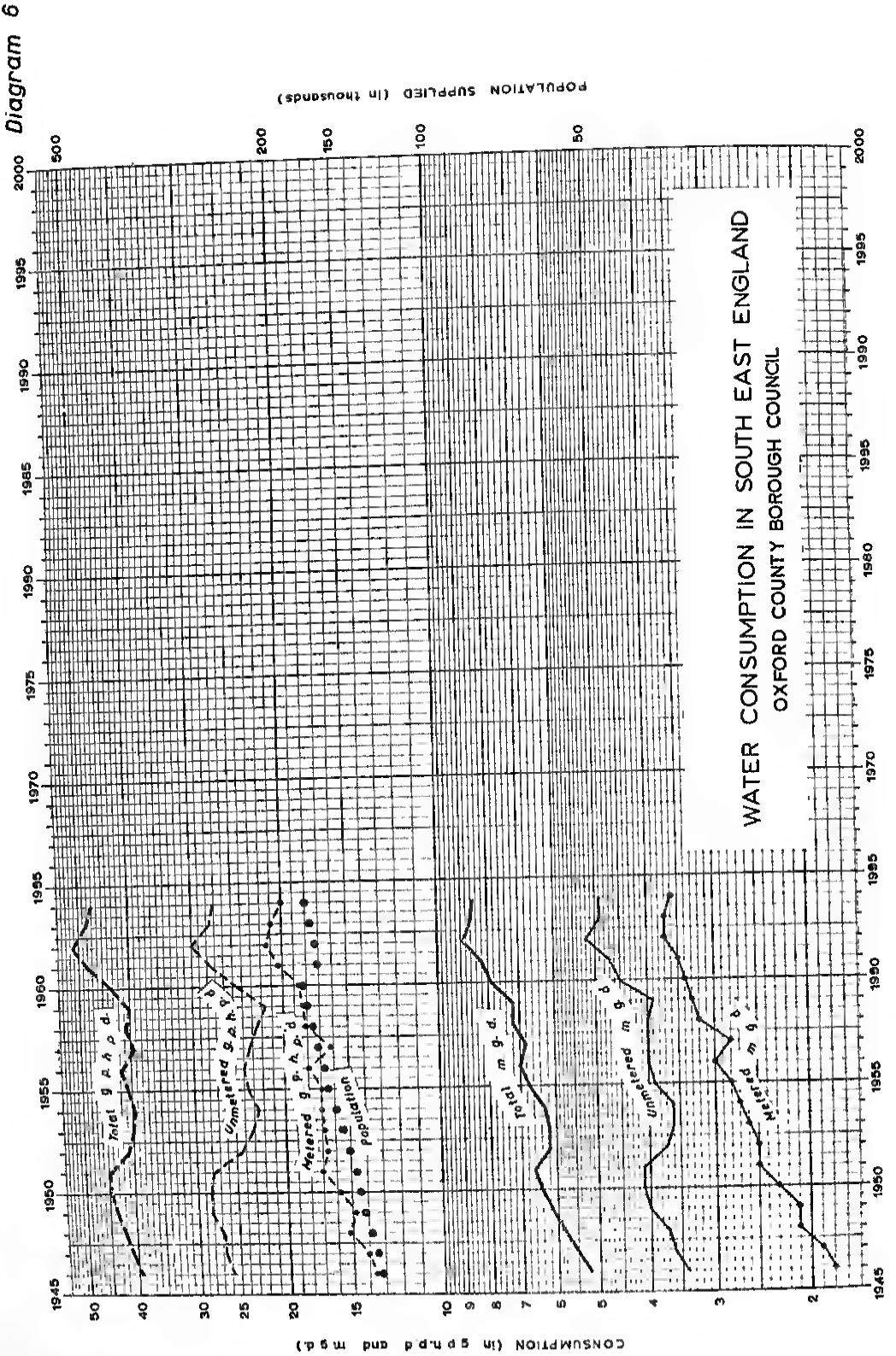
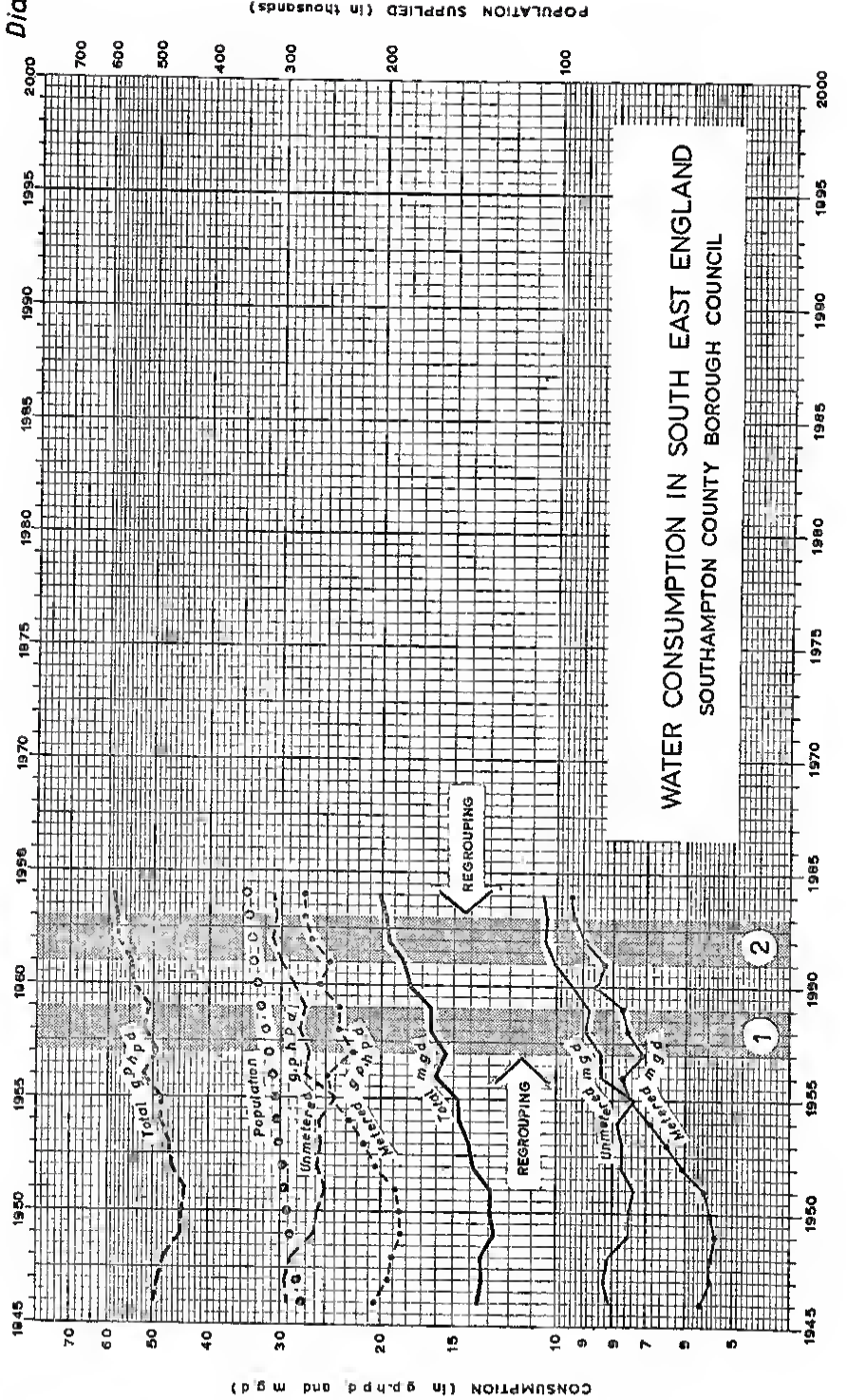


Diagram 7



APPENDIX III

Appendix III

AGRICULTURAL DEMANDS

Welland and Nene River Authority Area

		SPRAY IRRIGATION								Other Demands (e.g. Stock)
		Source - Acres under Irrigation			Total Acreage under Irrigation	Consumption in Year of Maximum Demand				
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	Ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1965) (Analysis of Licences of Right)	High value crops				2,970	340	5	5	0.9	3.4
	Low value crops				2,720	310	5	5	0.8	
	Total	4,600	60	1,030	5,690	650	5	10	1.7	
1971	High value crops				4,750	540	5	9	1.5	4
	Low value crops				4,550	510	5	8	1.4	
	Total	4,650	3,600	1,050	9,300	1,050	5	17	2.9	
1981	High value crops				7,800	880	5	14	2.4	5
	Low value crops				7,500	850	5	14	2.3	
	Total	5,400	8,500	1,400	15,300	1,730	5	28	4.7	
2001	High value crops				14,000	1,600	5	26	4.4	7
	Low value crops				13,500	1,500	5	24	4.1	
	Total	6,300	18,600	2,600	27,500	3,100	5	50	8.5	
Ultimate Limits (M.A.F.F.*)	High value crops				40,100	4,500	5	72	12.5	
	Low value crops				23,900	2,700	5	43	7.5	
	Total	6,300	55,000	2,700	64,000	7,200	5	115	20.0	

*_*Ministry of Agriculture, Fisheries and Food*

AGRICULTURAL DEMANDS

Great Ouse River Authority

		SPRAY IRRIGATION								Other Demands (e.g. Stock)
		Source – Acres under Irrigation			Total Acreage under Irrigation	Consumption in Year of Maximum Demand				
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1962) (M.A.F.F.* census)	High value crops				20,300	2,300	5	37	6.3	
	Low value crops				9,700	1,100	5	18	3.0	5.4
	Total	23,600	500	5,900	30,000	3,400	5	55	9.3	
1971	High value crops				36,200	4,100	5	66	11.0	
	Low value crops				22,100	2,500	5	40	7.0	7.8
	Total	37,400	10,400	10,500	58,300	6,600	5	106	18.0	
1981	High value crops				53,000	6,000	5	96	16.0	
	Low value crops				35,400	4,000	5	64	11.0	9.2
	Total	47,800	25,100	15,500	88,400	10,000	5	160	27.0	
2001	High value crops				68,000	7,700	5	123	21.0	
	Low value crops				53,000	6,000	5	96	16.0	12.0
	Total	61,600	39,700	19,700	121,000	13,700	5	219	37.0	
Ultimate Limits (M.A.F.F.*)	High value crops				68,000	7,700	5	123	21	
	Low value crops				62,000	7,000	5	112	19	
	Total	68,600	51,700	19,700	130,000	14,700	5	235	40	

* *Ministry of Agriculture, Fisheries and Food*

AGRICULTURAL DEMANDS

East Suffolk and Norfolk River Authority Area

		SPRAY IRRIGATION								Other Demands (e.g. Stock)
		Source – Acres under Irrigation			Total Acreage under Irrigation	Consumption in Year of Maximum Demand				
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	Ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1965)	High value crops				14,200	1,610	5	26	4.4	
	Low value crops				14,000	1,590	5	25	4.4	
	Total	14,100		14,100	28,200	3,200	5	51	8.8	
1971	High value crops				20,000	2,260	5	36	6.2	
	Low value crops				19,600	2,220	5	36	6.1	
	Total	14,100	3,000	22,500	39,600	4,480	5	72	12.3	
1981	High value crops				26,000	2,940	5	47	8.1	
	Low value crops				28,000	3,170	5	51	8.7	
	Total	14,100	6,500	33,400	54,000	6,110	5	98	16.8	
2001	High value crops				26,000	2,940	5	47	8.1	
	Low value crops				45,000	5,100	5	82	14.0	
	Total	14,100	11,800	45,100	71,000	8,040	5	129	22.1	
Ultimate Limits (N.A.F.F.*)	High value crops				26,000	2,940	5	47	8.1	
	Low value crops				75,200	8,500	5	136	23.3	
	Total	14,100			101,200	11,440	5	183	31.4	

** Ministry of Agriculture, Fisheries and Food*

AGRICULTURAL DEMANDS

Essex River Authority Area

		SPRAY IRRIGATION								Other Demands (e.g. Stock)
		Source – Acres under Irrigation			Total Acreage under Irrigation	Consumption in Year of Maximum Demand				
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	Ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1965) (Analysis of Licences of Right)	High value crops				12,000	1,360	5	22	3.7	
	Low value crops				3,000	340	5	5	0.9	
	Total	6,500	4,000	4,500	15,000	1,700	5	27	4.6	
1971	High value crops				16,200	1,830	5	29	5.0	
	Low value crops				5,100	580	5	9	1.6	
	Total	6,500	9,500	5,300	21,300	2,410	5	38	6.6	
1981	High value crops				22,000	2,490	5	40	6.8	
	Low value crops				8,000	900	5	14	2.5	
	Total	8,500	15,500	6,000	30,000	3,390	5	54	9.3	
2001	High value crops				25,000	2,830	5	45	7.8	
	Low value crops				12,000	1,360	5	22	3.7	
	Total	11,000	18,500	7,500	37,000	4,190	5	67	11.5	
Ultimate Limits (M.A.F.F.*)	High value crops				25,000	2,830	5	45	7.8	
	Low value crops				28,000	3,170	5	51	8.7	
	Total	21,000	22,500	9,500	53,000	6,000	5	96	16.5	

* *Ministry of Agriculture, Fisheries and Food*

Appendix III

AGRICULTURAL DEMANDS

Lee Conservancy Catchment Board Area

		SPRAY IRRIGATION								Other Demands (e.g. Stock)
		Source – Acres under irrigation			Total Acreage under irrigation	Consumption in Year of Maximum Demand				
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1965)	High value crops				2,500	280	5	5	0.8	8.0
	Low value crops				750	90	5	1	0.2	
	Total	3,000		250	3,250	370	5	6	1.0	
1971	High value crops				3,650	410	5	7	1.1	8.0
	Low value crops				1,100	120	5	2	0.3	
	Total	4,000		750	4,750	530	5	9	1.4	
1981	High value crops				5,700	640	5	10	1.8	8.0
	Low value crops				1,800	200	5	3	0.5	
	Total	5,700		1,800	7,500	840	5	13	2.3	
2001	High value crops				5,700	640	5	10	1.8	8.0
	Low value crops				2,900	330	5	5	0.9	
	Total	6,800		1,800	8,600	970	5	15	2.7	
Ultimate Limits (M.A.F.F.*)	High value crops				5,700	640	5	10.0	1.8	
	Low value crops				6,800	770	5	12.0	2.1	
	Total	11,000		2,500	12,500	1,410	5	22.0	3.9	

* *Ministry of Agriculture, Fisheries and Food*

NOTE: 'Other demands' include those for horticulture (cultivation under glass)

AGRICULTURAL DEMANDS

Thames Conservancy Area

		SPRAY IRRIGATION								Other Demands (e.g. Stock)
		Source - Acres under Irrigation			Total Acreage under Irrigation	Consumption in Year of Maximum Demand				
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1962) (M.A.F.F.* CENSUS)	High value crops				7,000	800	5	13	2.2	
	Low value crops				9,000	1,000	5	16	2.7	0.5
	Total	12,800	160	3,040	16,000	1,800	5	29	4.9	
1971	High value crops				11,500	1,300	5	21	3.6	
	Low value crops				14,300	1,600	5	26	4.4	0.6
	Total	18,200	2,600	5,000	25,800	2,900	5	47	8.0	
1981	High value crops				13,600	1,550	5	25	4.3	
	Low value crops				23,000	2,600	5	42	7.1	0.7
	Total	23,600	5,800	7,200	36,600	4,150	5	67	11.4	
2001	High value crops				13,600	1,550	5	25	4.3	
	Low value crops				40,000	4,500	5	72	12.0	1.0
	Total	32,200	10,700	10,700	53,600	6,050	5	97	16.3	
Ultimate Limits (M.A.F.F.*)	High value crops				13,600	1,550	5	25	4.3	
	Low value crops				61,400	6,950	5	111	19.1	
	Total				75,000	8,500	5	136	23.4	

* *Ministry of Agriculture, Fisheries and Food*

AGRICULTURAL DEMANDS

Kent River Authority Area

		SPRAY IRRIGATION							Other Demands (e.g. Stock)
		Source – Acres under irrigation			Total Acreage under irrigation	Consumption in Year of Maximum Demand			
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	ins.	m.g.d.	m.g.d.	m.g.d.
1962 (M.A.F.F.* Census)	High value crops				13,000		5			
	Low value crops				3,050		5			
	Total				16,050		5			
PRESENT (1965) (Analysis of Licences of Right)	High value crops				16,450	1,860	5	30	5.1	
	Low value crops				3,640	410	5	7	1.1	0.5
	Total	16,970	610	2,510	20,090	2,270	5	37	6.2	
1971	High value crops				23,250	2,630	5	42	7.2	
	Low value crops				4,920	560	5	9	1.5	0.6
	Total	20,000	5,030	3,140	28,170	3,190	5	51	8.7	
1981	High value crops				34,600	3,920	5	63	10.7	
	Low value crops				6,900	780	5	12	2.1	0.7
	Total	20,000	18,360	3,140	41,500	4,700	5	75	12.8	
2001	High value crops				49,340	5,580	5	89	15.3	
	Low value crops				10,800	1,220	5	20	3.3	1.0
	Total	20,000	37,000	3,140	60,140	6,800	5	109	18.6	
Ultimate Limits (M.A.F.F.*)	High value crops				49,340	5,580	5	89	15.3	
	Low value crops				23,710	2,680	5	43	7.3	
	Total	20,000	49,290	3,760	73,050	8,260	5	132	22.6	

* *Ministry of Agriculture, Fisheries and Food*

AGRICULTURAL DEMANDS

Sussex River Authority

		SPRAY IRRIGATION							Other Demands (e.g. Stock)
		Source – Acres under Irrigation			Total Acreage under Irrigation	Consumption in Year of Maximum Demand			
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1965)	High value crops				3,250	368	5	6	1.0	
	Low value crops				3,250	368	5	6	1.0	5
	Total	3,900	650	1,950	6,500	735	5	12	2.0	
1971	High value crops				5,000	565	5	9	1.6	
	Low value crops				5,000	565	5	9	1.6	6
	Total	4,700	2,200	3,100	10,000	1,130	5	18	3.2	
1981	High value crops				5,600	630	5	10	1.7	
	Low value crops				7,250	820	5	13	2.2	7
	Total	5,000	3,700	4,150	12,850	1,450	5	23	3.9	
2001	High value crops				5,600	630	5	10	1.7	
	Low value crops				11,500	1,300	5	21	3.6	10
	Total	5,000	6,050	6,050	17,100	1,930	5	31	5.3	
Ultimate Limits (M.A.F.F.*)	High value crops				5,600	630	5	10	1.7	
	Low value crops				26,400	2,970	5	48	8.1	
	Total				32,000	3,600	5	58	9.8	

* *Ministry of Agriculture, Fisheries and Food*

Appendix III

AGRICULTURAL DEMANDS

Hampshire River Authority Area

		SPRAY IRRIGATION								Other Demands (e.g. Stock)
		Source – Acres under irrigation			Total Acreage under Irrigation	Consumption in Year of Maximum Demand				
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1963)	High value crops	1,486			1,486	170	5	3	0.5	
	Low value crops	1,587		327	1,914	220	5	4	0.6	
	Total	3,073		327	3,400	390	5	7	1.1	
1971	High value crops	1,774	622	172	2,568	290	5	5	0.8	
	Low value crops	2,018	748	546	3,312	370	5	6	1.0	
	Total	3,792	1,370	718	5,880	660	5	11	1.8	
1981	High value crops	2,009	1,654	261	3,924	450	5	7	1.2	
	Low value crops	2,667	1,581	828	5,076	580	5	9	1.6	
	Total	4,676	3,235	1,089	9,000	1,030	5	16	2.8	
2001	High value crops	1,477	2,223	260	3,960	450	5	7	1.2	
	Low value crops	3,657	3,063	1,320	8,040	900	5	14	2.5	
	Total	5,134	5,286	1,580	12,000	1,350	5	21	3.7	
Ultimate Limits (M.A.F.F.*)	High value crops				3,960	450	5	7	1.2	
	Low value crops				8,040	900	5	14	2.5	
	Total				12,000	1,350	5	21	3.7	

* *Ministry of Agriculture, Fisheries and Food*

AGRICULTURAL DEMANDS

Avon and Dorset River Authority Area

		SPRAY IRRIGATION								Other Demands (e.g. Stock)
		Source – Acres under Irrigation			Total Acreage under Irrigation	Consumption in Year of Maximum Demand				
		Water Course		Ground Water Acres		Seasonal Total		Peak Daily	Average Daily	
		Direct (Summer) Acres	Local Storage (Winter) Acres		Acres	m.g.	ins.	m.g.d.	m.g.d.	m.g.d.
PRESENT (1965) (Analysis of Licences of Right)	High value crops	1,000		330	1,330	150	5	2	0.4	6
	Low value crops	8,300	200	3,200	11,700	1,325	5	21	3.6	
	Total	9,300	200	3,530	13,030	1,475	5	23	4 0	
1971	High value crops	1,210		450	1,650	190	5	3	0.5	7
	Low value crops	10,250	400	3,590	14,250	1,610	5	26	4.4	
	Total	11,460	400	4,040	15,900	1,800	5	29	4.9	
1981	High value crops	1,710		550	2,250	250	5	4	0.7	9
	Low value crops	10,250	400	3,590	14,250	1,610	5	26	4.4	
	Total	11,960	400	4,140	16,500	1,860	5	30	5.1	
2001	High value crops	1,710		550	2,250	250	5	4	0.7	12
	Low value crops	10,250	400	3,590	14,250	1,610	5	26	4.4	
	Total	11,960	400	4,140	16,500	1,860	5	30	5.1	
Ultimate Limits (M.A.F.F.*)	High value crops	1,710		550	2,250	250	5	4	0.7	
	Low value crops	10,250	400	3,590	14,250	1,610	5	26	4.4	
	Total	11,960	400	4,140	16,500	1,860	5	30	5.1	

** Ministry of Agriculture, Fisheries and Food*

APPENDIX IV

POTENTIAL RESOURCES

Welland and Nene River Authority Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate cost delivered to service reservoirs (pence per thousand gallons)* under 24	24 to 36	over 36	Remarks
								*For comparison the cost delivered to service reservoirs for supplies in this area is approximately 24 pence per thousand gallons.
(i)	**Schemes specific to immediate local needs**							
1	Earls Barton, Northants – gravels.	0.4	Experience of existing gravel sources	Higham Ferrers & Rushden Water Board area	✓			
2	Lyddington – increased abstraction.	0.3	Estimated	Southern part of Rutland	✓			
3	Peterborough, Greatford Area – watercress beds.	1.5	Estimates based on information from previous or present owners	Peterborough City and southern part of present South Lincolnshire Water Board area	✓			
4	Peterborough, Greatford Area – further watercress beds.	4.5						
5	Peterborough – boreholes (British Railways).	2.0						
6	Aslackby & Rippingly – boreholes in Lincs limestone.	6.0	Test pumping	Peterborough	✓			This source, in the Lincolnshire River Authority area, would be of considerable value.
7	Tallington – gravel pits.	1.0 minimum		Peterborough City	✓			
8	Nene Valley – development of existing abstractions – gravels.	1.0 minimum	Experience of existing gravel sources	Nene & Ouse Water Board area.	✓			
9	Sywell Reservoir (2½ miles N.E. of Northampton) – construction of a dam downstream of existing dam and operation of pumped storage scheme – River Nene or local gravels.	2.0 to 3.0	Increase in storage from 200 to 2,000 m.g. 1943/44 river flows	Mid-Northamptonshire Water Board, Higham Ferrers & Rushden Water Board areas	✓			Land submerged: additional 150 acres – classification 4G/2A.
(ii)	**Major schemes for supply within river authority area**							
10	Intakes on River Nene in the Elton/Wansford area (8 miles west-south-west of Peterborough) and on River Welland in the Tixover/Duddington area (5 miles south-west of Stamford) with pumped storage reservoirs at Empingham and Menton.	50 plus	River flow records	Mid-Northamptonshire Water Board area		✓		Land submerged: 3,000 acres – classification 6AG. (Empingham) Land submerged: 1,600 acres – classification 3G/2A. (Menton)
(iii)	**Regional schemes**							
	None.							
(iv)	**Barrages**							
	The Wash.							See Great Ouse, scheme 19.

POTENTIAL RESOURCES

Great Ouse River Authority Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoire (pence per thousand gallons)* under 24	24 to 36	over 36	Remarks
								* *For comparison, the cost delivered to service reservoirs for present supplies is approximately 17 pence per thousand gallons.*
(i)	**Schemes specific to immediate local needs**							
1	Melbourn – chalk borehole.	3.0	Test pumping	Cambridgeshire	✓			
2	Brandon – chalk borehole.	0.5		Mildenhall, Suffolk	✓			
3	Hillington – greensand borehole.	1.0		King's Lynn	✓			
4	Slip End – chalk borehole.	1.0		Hertfordshire	✓			
5	Wendens Ambo – chalk borehole.	1.5	Estimates based on percolation	Hertfordshire & Essex	✓			
6	Little Chesterford – chalk borehole.	1.5 to 2.0		Hertfordshire & Essex	✓			
7	Houghton, St. Ives, Hunts – gravel borehole.	0.5		Huntingdonshire	✓			
8	Spring Lodge – chalk borehole.	1.0		Wisbech & District	✓			
9	Barrow Heath – chalk borehole.	2.0		West Suffolk	✓			
10	Ixworth – chalk – increased abstraction from borehole.	1.1	Test pumping	West Suffolk	✓			
(ii)	**Major schemes for supply within river authority area**							
11	Stoke Ferry – intake on River Wissey and flood relief channel.	6	Estimate	King's Lynn		✓		
12	Stewartby brickpits – storage.	≠10 to 20	See remarks			(?)✓		≠ Depends on number of brick pits available: yield severely reduced by 17.
(iii)	**Regional schemes**							
13	Diddington (Grafham Water) – second intake on the River Bedford Ouse.	ø15				✓		ø Yield dependent on m.a.f. to be imposed at Brownshill Staunch.
14	Abbotsley – pumped storage reservoir.	32	1933–64 river flow records (see Report on The Water Resources of the Great Ouse Basin)			✓		Land submerged: 2,200 acres – classification 1A and 2A.. Supersedes 13.
15	Ely Ouse – river abstraction discharging to Essex Rivers.	22				✓		
16	Great Bradley – pumped storage reservoir.	59				✓		Land submerged: 1,800 acres – classification 5A and 2A Supersedes 15.

Great Ouse River Authority Area (contd.)

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
(iii)	**Regional schemes**							
17	Whitchurch, near Aylesbury – pumped storage reservoir.	29	1933–64 river flow records (see Report on The Water Resources of the Great Ouse Basin)			✓		Land submerged: 1,600 acres – classification 4G. Supersedes 12. To be reviewed in conjunction with proposals for abstraction from River Themes (see Thames 16).
18(a)	Chalk aquifer (first stage): controlled abstraction of natural percolation.	80			✓			Stated yields available for "export" after maintaining a flow of 70 m.g.d. at Denver Sluice.
(b)	Chalk aquifer (second stage). regulation or recharge of surface run-off.	45 (additional)	(Theoretical assessment)				✓	Alternative to 16 and would supersede 15.
(iv)	**Barrages**							
19	The Wash.	400–620	As above (reliability curves of cumulative run-off)				✓	Five years required for investigation and preliminary designs, eight to ten years for construction.

POTENTIAL RESOURCES

East Suffolk and Norfolk River Authority Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)* under 24	24 to 36	over 36	Remarks
								* *For comparison, the cost delivered to service reservoirs for present supplies in this area is approximately 17 pence per thousand gallons.*
(i)	**Schemes specific to immediate local needs**							
1	School Lane, Helesworth – chalk borehole.	0.26	Pilot bore	Halesworth	✓			
2	Benhell – chalk borehole.	0.75	Comparison with other bores nearby	Blyth	✓			
3	Walpole – increased usa – chalk borehole.	0.43	Yield test	Blyth	✓			
4	Walpole – chalk borehole.	0.75	Comparison with other bores nearby	Blyth	✓			
5	Waveney Valley – chalk borehole.	2.0	Comparison with other bores nearby	Lowestoft	✓			
6	Saxmundham area – chalk borehole.	2.0	Comparison with other bores nearby	Sizewell nuclear power station & Blyth	✓			
(ii)	**Major schemes for supply within river authority area**							
7	Washbrook, near Ipswich. Pumped storage, direct supply reservoir on Belstead Brook 5,000 m.g. storage. Abstraction from R. Gipping at Ipswich and direct run-off.	7	Water Resources Board estimate of available run-off	Ipswich & South-East Suffolk		✓		Land submerged: 700 acres (full scheme) – classification 2A – Under consideration by Ipswich C.B.C.
7(a)	Extension of above scheme by intake on Essex Stour regulated from Ely Ouse.	7 +	Water Resources Board estimate of available run-off	Ipswich & South-East Suffolk		✓		
8	Waveney Valley	6	Estimate of percolation into chalk	Lowestoft	✓			Abstraction via gravels lower down river suggested for Waveney. Elsewhere water could be abstracted direct near tidal limit. Water abstracted from Stiffkey (otherwise too physically remote to be considered as a source) could be conveyed by R. Bure to Great Yarmouth area. Tests have been carried out on the R. Wensum near Norwich.
9	Yare–Wensum Valley	10		Norwich	✓			
10	Bure Valley	5		Great Yermouth	✓			
11	Stiffkey Valley	3		North Norfolk or Great Yermouth	✓			
	Pumping from chalk wells into headwaters of rivers to sustain flows.							
(iii)	**Regional schemes**							
	None.							

East Suffolk and Norfolk River Authority Area (contd.)

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
(iv)	**Barrage schemes**							
12	Barrage on R. Bure at Acle or Great Yarmouth to raise water level 1-2 ft. storage in existing rivers and Broads.	15	Hydrological survey estimate	Norfolk and North Suffolk	✓			Would affect navigational, recreational and naturalist interests. No land would be flooded but locks would be needed and conditions might be at least temporarily affected in natura reserves.

POTENTIAL RESOURCES

Essex River Authority Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
								* *For comparison, the average cost delivered to service reservoirs for present supplies in this area is approximately 19 pence per thousand gallons, whilst the cost of water from Hemingfield is about 29 pence per thousand gallons.*
(i)	**Schemes specific to immediate local needs**							
1	Flatford Mill/ Stratford St. Mary – direct river abstraction – R. Stour (Stour recirculation scheme).	2.6	Cumulative mass curve for years 1933/35 and 1947/50	South Essex	✓			
2	Abberton Reservoir – installation of pumps and mains to take flood water from river to reservoir – R. Roman.	1.0	Not sufficient data for more than good guess. 1964/65 run-off figures show estimate of right order	South Essex	✓			
(ii)	**Major schemes for supply within river authority area**							
3	Abstraction from R. Colne at lowest point – storage of flood water at Ardleigh	8	Records extended for 30 years by correlation between Stour and Colne	Colchester/ Tendring		✓		Land submerged: 200 acres Ardleigh site – classification 2A
4	Abstraction from R. Colne at Earls Colne – storage of flood water at Halstead	5	Records extended for 30 years by correlation between Stour and Colne	Colchester/ Tendring		✓		Land submerged: 400 acres Halstead site – classification 2A. Possibility of increased yield using water from Great Ouse area.
5	Maldon. Storage reservoir to store flood flows of R. Chelmer/ Blackwater.	13	Long period recorded river flows	Southend & District			✓	Land submerged: 1,365 acres – classification 6AG.
6	Ingatestone. Pumped storage reservoir, to store flood waters of R. Roding plus small supply from R. Wid.	7	Initially hydrological survey report. Also by synthetic mass run-off curve for 1933/35	South Essex		✓		Land submerged: (two reservoirs): 500 & 345 acres – classification 6AG.
(iii)	**Regional schemes**							
	None – other than Great Bradley included under Great Ouse River Authority area, Scheme 16							
(iv)	**Barrages**							
7	Crouch estuary.	22	Consultants' rough preliminary estimate based on run-off records	Southend & South-East Essex			✓	Scheme not economically attractive. Strong amenity objections likely. Land drainage problems. Scheme only viable at all if effluent received at all times.

POTENTIAL RESOURCES

Lee Conservancy Catchment Board Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
								* *For comparison, the cost delivered to service reservoirs for present supplies in this area excluding Metropolitan Water Board is approximately 15 pence per thousand gallons. The cost in the Metropolitan Water Board's area is about 27 pence per thousand gallons.*
(i)	**Schemes specific to immediate local needs**							
1	North Stortford – chalk borehole.	1.5	Test pumping	Bishops Stortford & Stansted Mountfitchet districts	✓			Licence granted by Catchment Board for 10 years – order awaited.
(ii)	**Major schemes for supply within Catchment Board area**							
	None – but see (iii) below.							
(iii)	**Regional schemes**							
2	Cobbins Brook near Waltham Abbey – pumped storage reservoir (18,000 – 20,000 m.g.).	58	1943/44 Thames and Lee flows: assuming reservoir followed immediately upon the construction of Wraysbury and Datchet (Metropolitan Water Board) reservoirs in Thames Valley	Hertfordshire & Essex		✓		Land submerged: 1,700 acres – classification 2A – but including a sewage ferm. Scheme involves transfer of Thames water to storage in Lee area. The diversion of roads and an electricity supergrid transmission line would be required.
(iv)	**Barrages**							
	None.							

POTENTIAL RESOURCES

Thames Conservancy Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)* under 24	24 to 36	over 36	Remarks
								* *For comparison, the cost delivered to service reservoirs for present supplies in this area excluding Metropolitan Water Board, is approximately 22 pence per thousand gallons. The cost in the Metropolitan Water Board's area is about 27 pence per thousand gallons*
(i)	**Schemes specific to immediate local needs**							
1	Increased abstraction – Sor Brook, Banbury.	0.5	Flow records	Banbury	✓			
2	Direct abstraction – R. Wey, Guildford.	4.0		Guildford area	✓			
3	Increased abstraction – R. Windrush, Worsham Waterworks, Witney.	0.6		Oxford	✓			
4	Direct abstraction – R. Thames, Chertsey.	1.0 (average) 3.0 (max. day)		North-West Surrey	✓			
5	Taplow (Slough) – chalk borehole.	2.0+	Pumping tests	Slough	✓			
6	Ewell (Howell Hill) – chalk borehole.	2.0	Estimate of resources of catchment	Sutton & part Epsom	✓			
7	Axford (Kennet) – chalk borehole.	3.0	Estimate of resources of catchment	Swindon	✓			
8	Between Northleach and Bourton-on-Water – borehole.	0.5 to 1.0	Geological advice	East Gloucestershire	✓			
9	Fairford – oolites borehole.	0.5	Present abstraction	East Gloucestershire	✓			Possible acquisition of two existing boreholes from the Ministry of Defence.
10	Kingsclere – chalk – additional boreholes at existing well station.	1.5	Assessment of catchment	Northern Hampshire	✓			Partly for use outside Thames catchment.
11	Clanddn – lower greensand borehole.	1.0 to 3.0	Test on existing borehole	North-West Surrey		✓		
12	Grove Waterworks, Watford.	1.0	Estimate of resources of catchment	Watford	✓			Yield estimated some years ago – now a possible risk of overpumping the catchment.
13	Chertsey – gravel boreholes.	5.0 to 6.0		Woking area	✓			Doubtful whether the Company will proceed with this proposal.

Thames Conservancy Area (contd.)

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
(ii)	**Major schemes for supply within Conservancy area**							
14	Berkshire Downs – chalk boreholes.	11	Estimate of resources of catchment	Upper Thames Valley	✓			Consent given for drilling and test pumping only.
15	Medmenham – chalk – 6 boreholes.	10	Estimate of resources of catchment	Buckinghamshire	✓			
(iii)	**Regional schemes**							
16	Pumped storage reservoirs at Waddesdon and Whitchurch, near Aylesbury. Intake on R. Thames near Medmenham.	70 (for 25,000 m.g. storage capacity)	1943/44 river flows: allowing for prior claims of Metropolitan Water Board reservoirs			✓		Land submerged: Waddesdon 1,700 acres – classification 3G and 2A; Whitchurch 1,600 acres – classification 4G. Reservoirs about 20 miles from intake. Waddesdon site adjacent to National Trust land. (To be reviewed in conjunction with Great Ouse proposals; see Great Ouse scheme 17.)
17	Berks, East Wilts and Oxon – boreholes. Ground water to be abstracted from chalk and oolite aquifers to regulate flow of river.	30–1971 125–1981 200–1991+	Consultant's estimate, based on hydro-geological study of area		✓ (Upper Thames)	✓ (Bucks, London, Colne (Thames), Upper Lee & South Essex)		Will ensure direct river supplies for statutory water undertakings and other users. Total cost about £8 million. Cost at abstraction points about 3 pence per thousand gallons – additional costs for pumping charges and for mains from abstraction to supply points. Possible opposition from statutory water undertakings using boreholes in the Thames Valley.
18	Possible sites for large regulating reservoirs:– Bampton (45,000 m.g.) Enborne (55,000 m.g.) Otmoor (32,000 m.g.)	approx. 70 85 55	1943/44 river flows			✓ (Upper Thames)	✓ (other areas)	Classification of land submerged; Bampton 3G, 6,000 acres, Enborne 9H and 6AG, 7,500 acres, Otmoor 7G, 3,000 acres. Yields require detailed analysis and should not be added.
17a 18a	Direct river abstraction at Sunnymeads near Windsor.	15 – 1971 35 – 1981 85 – 2001		Colne Valley, Rickmansworth & Uxbridge Valley, & Lee Valley Water Companies areas				Development unlikely during the next 20 years if ground-water scheme achieves estimated yield.
17b 18b	Increased abstraction from R. Thames for Metropolitan Water Board.			Greater London				Dependent upon 17 and/or 18 above.
(iv)	**Barrages** None.							No barrage proposals for the Thames have been considered by the Committee.

POTENTIAL RESOURCES

Kent River Authority Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
								* *For comparison, the cost delivered to service reservoirs for present supplies in this area is approximately 16 pence per thousand gallons.*
(i)	**Schemes specific to immediate local needs**							
1	Eastry – ground water.	2.5	Engineers' estimate of percolation, catchment area, etc., together with local knowledge of aquifer	Thanet	✓			Dependent on cessation of discharge of coal mine drainage on to the chalk outcrop.
2	Knowlton – ground water.				✓			
3	Finglesham – ground water.	1.0		Thanet	✓			
4	Lower Hardres – ground water.	1.5		Thanet	✓			
5	Temple Ewell – ground water.	1.5		Dover	✓			
6	Poulton Farm – ground water.	1.0		Dover	✓			
7	Alkham – ground water.	1.0		Folkestone	✓			
8	Acrise/Denton – ground water.	3.0		Folkestone	✓			
9	Denge Beach – ground water.	1.0		Folkestone	✓			
10	Chartham – ground water.	3.0		Canterbury/Mid-Kent	✓			Dependent upon abstraction of additional water from aquifer to supplement low flows in R. Stour.
11	Chilham – ground water.	3.0		Mid-Kent	✓			
12	Herrietsham – ground water.	0.5		Mid-Kent	✓			
13	Rolvenden – ground water.	0.5		Mid-Kent	✓			
14	Maytham – ground water.	0.5		Mid-Kent	✓			
15	Ridley – ground water.	0.5		Mid-Kent	✓			
16	Bodiam – ground water.	1.0	Test pumping	Eastbourne	✓			
17	Littlebourne – ground water.	1.0	Percolation, etc.	Thanet	✓			
18	Northbourne – ground water.	1.0	Percolation, etc.	Thanet	✓			
19	Belmont (extra from existing ground water source).	1.0	Test pumping	Medway/Maidstone	✓			
20	Selling/Boughton Street (extra from existing ground water source).	1.0	Test pumping	Medway/Maidstone	✓			
21	Highsted (extra from existing ground water source).	1.0	Test pumping	Medway/Maidstone	✓			
22	Stockbury – ground water.	1.0	Percolation, etc.	Medway/Maidstone	✓			
(ii)	**Major schemes for supply within river authority area**							
23	Broadoak – R. Stour – pumped storage reservoir.	14	Limited records of river flow	North-East Kent		✓		Intake below Canterbury.

Kent River Authority Area (contd.)

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)			Remarks
					under 24	24 to 36	over 36	
24	Bewl Bridge – R. Medway and tributaries – pumped storage reservoir – (6,900 m.g.).	4 to 25	Limited river flow records and assumed minimum acceptable flows. Practicable full development of catchment area	Medway/ Mid-Kent/ Maidstone		√		Land submerged: 600 acres. To be developed in stages. Statutory powers to be sought shortly.
25	Lamberhurst, Winbridge or Oundle (Pembury) – R. Medway and tributaries – further reservoirs for investigation.	15						
26	Rolvenden/Newenden – R. Rother – pumped storage reservoir.	12	Limited river flow records	Mid-Kent		√		The yields are NOT additive. Further preliminary investigation required. Schemes 23 to 27 would use land classification 6AG.
27	Turks Bridge – R. Rother – impounding reservoir.	5	Limited river flow records	Eastbourne & Mid-Sussex		√		
(iii)	**Regional schemes** None							
(iv)	**Barrages** None							

POTENTIAL RESOURCES

Sussex River Authority Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
								*For comparison, the cost delivered to service reservoirs for present supplies in this area is approximately 12 pence per thousand gallons for ground-water and 20 pence per thousand gallons for surface water resources
(i)	**Schemes specific to immediate local needs**							
1	Waller's Haven, Ninfield – pumped storage reservoir – additional yield to Hazards Green.	1.0		Eastbourne		✓		
2	Penhurst – borehole in Ashdown Sands.	0.5		Eastbourne		✓		
3	Cradle Valley, Alfriston – borehole in chalk.	0.75		Eastbourne	✓			
4	Pulborough – boreholes in Lower Greensand.	4.0		North-West Sussex Water Board	✓			
5	Bulverhythe Level – impounding reservoir on Combe Haven up to 1,600 m.g.	2.0	Mean run-off and storage capacity	Bexhill/Hastings		✓		Scheme put forward by River Authority as being prima facia feasible on hydrological grounds.
6	R. Cuckmere – pumped storage reservoir in tributary valley – 770 m.g.	5.0	Consultant's estimate on stream flows	Eastbourne			✓	Land submerged: 125 acres – classification 6AG and 7G. Exploratory borings now in progress.
(ii)	**Major schemes for supply within river authority area**							
7	Uckfield, Ardingly and Haywards Heath – R. Sussex Ouse – regulating and/or direct supply reservoirs.	15	Storage capacity and river gaugings since 1959	Mid-Sussex/ Brighton		✓		Land submerged – classification 6AG. More than one impounding reservoir would be required to achieve this yield – but source could be developed in stages.
(iii)	**Regional schemes**							
8	Havant – Chichester – Arundel area between South Downs and the coast west of R. Arun – chalk boreholes to develop chalk catchment fully.	16	Percolation into chalk formation		✓			This scheme is to a limited extent an alternative to (9) below.
(iv)	**Barrages**							
9	Chichester Harbour – partly pumped storage from R. Arun 12,000–14,000 m.g. nett storage with T.W.L. 7.0–8.5 O.D.	35 to 40	Run-off in 3 dry-year period					Only a brief preliminary investigation of this scheme has been made based on direct run-off and pumped storage of winter flows from the R. Arun. No unit cost estimate has yet been made.

Appendix IV

POTENTIAL RESOURCES

Hampshire River Authority Area

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
								**For comparison, the cost delivered to service reservoirs for present supplies in this area is approximately 18 pence per thousand gallons.*
(i)	**Schemes specific to immediate local needs**							
1	Meon Valley – chalk borehole.	2.0	Pumping test	Portsmouth	✓			
2	Andover Pumping Station – chalk beds – boreholes.	2.0 to 3.0	Estimate of percolation	North Hampshire	✓			
3	Easton – chalk – increased abstraction from existing well.	0.5 (additional)	Present yield	Winchester	✓			Present abstraction 2.0 m.g.d.
4	Broughton – chalk borehole.	0.5	Present yield	North Hampshire	✓			Present abstraction .38 m.g.d.
5	Ibthorpe – chalk borehole.	0.3	Estimate of percolation	North Hampshire	✓			
6	Winchester area – chalk boreholes.	3.0		Winchester	✓			
(ii)	**Major schemes for supply within river authority area**							
7	Hevant Thicket – springs at Hevant and Bedhampton and surplus water from R. Ems. Impounding reservoir 1,500 m.g. capacity.	5	Depletion curve	Portsmouth		✓		Land submerged: 350 acres – classification 4G. Pumped storage scheme. Yield supported by long-term (1900) records. May be deferred until Itchen abstraction scheme is developed.
8	Below Eastleigh – R. Itchen – direct river abstraction.	15	River flow records	Portsmouth	✓			Feasible and economic – could lead to further development with pumped storage or regulating schemes.
9	R. Test – direct river abstraction.	20	River flow	Southampton	✓			Feasible and economic. Adequate river flows. Yield includes 8 m.g.d. already authorised but omitted from Appendix I.
10	Southampton area – underground sources – boreholes.	30	General assessment of yield from the chalk outcrop	Portsmouth/ Southampton	✓			
11	Various proposed sites in the tertiary deposits mainly in the lower reaches of the valleys of the Rivers Test, Itchen and Meon: pumped storage reservoirs.	80	River flow records	Portsmouth/ Southampton		✓		River flows adequate – reservoir sites subject to investigation on lands of various classifications.
(iii)	**Regional schemes** None.							
(iv)	**Barrages** None.							

POTENTIAL RESOURCES

Avon and Dorset River Authority

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)*			Remarks
					under 24	24 to 36	over 36	
								*For comparison, the cost delivered to service reservoirs for present supplies in this area is approximately 15 pence per thousand gallons.
(i)	**Schemes specific to immediate local needs**							
1	Dewlish – chalk borehole.	2.0		Poole/East Dorset	✓			Local opposition to development. Even pumping tests may require compulsory powers.
2	Milborne – chalk – development of existing site.	1.5		Poole/East Dorset	✓			Local opposition likely.
3	Camp Down, Folly Farm, Salisbury – chalk borehole.	1.0		Salisbury	✓			
4	Bourton – Horton – greensands – borehole.	0.25	Estimate of percolation and catchment area – combined with local knowledge of aquifer	North Wiltshire	✓			Possible objection if it derogates from existing Licences or Right.
5	South of Urchfont and Chirton – greensands – borehole.	0.25		North Wiltshire	✓			
6	Shapwick – chalk – well.	3.0		Poole/East Dorset	✓			
7	Codford – chalk – development of existing site.	1.0 (additional)		West Wiltshire	✓			
8	Wylye Valley – chalk – borehole.	1.5 +		West Wiltshire	✓			in conjunction with 7.
9	Deverill Valley – chalk – borehole.	2.0		West Wiltshire	✓			
10	Berwick St. John – upper greensand – borehole.	0.1		West Wiltshire	✓			
11	West Stafford near Dorchester – chalk – three boreholes	4.0	Past abstraction	Poole/East Dorset	✓			Three existing boreholes sunk by A.E.A.– not being used at present time.
12	East Holme near Wareham – R. Frome – direct abstraction.	4.0	River flow records	Poole/East Dorset	✓			
13	Upper Allen Valley – chalk – boreholes.	4.0	Test pumping	Bournemouth	✓			Licence application submitted to River Authority – January, 1966.

Avon and Dorset River Authority (contd.)

Scheme No.	Location, Source, Type of Scheme	Probable Yield m.g.d.	Basis of Yield Computation	Distribution Area	Approximate Cost delivered to service reservoirs (pence per thousand gallons)			Remarks
					under 24	24 to 36	over 36	
(ii)	**Major schemes for supply within river authority area** None.							
(iii)	**Regional schemes**							
14	Salisbury Plain – chalk – development of ground-water to regulate flow of R. Kennet.	100+	Infiltration over the chalk outcrop					This proposal has not been investigated in detail.
(iv)	**Barrages** None.							

KEY TO LAND CLASSIFICATIONS

1A First class arable land

2A Good general purpose farm land (arable)

2AG Good general purpose farm land (arable and grassland)

3G First class grassland

4G Good but heavy grassland

5A Downland (arable)

5G Downland (grassland)

6AG Medium quality farm land (arable and grassland)

7G Poor quality heavy land (grassland)

9H Poor quality light land (heath)